INFORMATION SYSTEMS SECURITY & ASSURANCE SERIES

ISSA

Fundamentals of Information Systems Security

FOURTH EDITION

David Kim | Michael G. Solomon

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This book is dedicated to our readers and students and the IT professionals pursuing a career in information systems security. May your passion for learning IT security help you protect the information assets of the United States of America, our businesses, and the private data of our citizens.

–David Kim

To God, who has richly blessed me in so many ways.

–Michael G. Solomon

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Preface

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Purpose of This Text

This text is part of the Information Systems Security & Assurance (ISSA) Series from Jones & Bartlett Learning (*www.issaseries.com*). Designed for

courses and curriculums in IT Security, Cybersecurity, Information Assurance, and Information Systems Security, this series features a comprehensive, consistent treatment of the most current thinking and trends in this critical subject area. These titles deliver fundamental information security principles packed with real-world applications and examples. Authored by Certified Information Systems Security Professionals (CISSPs) and experienced cybersecurity consultants, this series delivers comprehensive information on all aspects of information security. Reviewed word for word by leading technical experts in the field, these texts are not just current but forward thinking—putting you in the position to solve the cybersecurity challenges not just of today but also of tomorrow.

Part I of this text on information security fundamentals focuses on new risks, threats, and vulnerabilities associated with the transformation to a digital world and the Internet of Things (IoT). Individuals, students, educators, businesses, organizations, and governments have changed how they communicate, share personal information and media, and do business. Led by the vision of the IoT, the Internet and broadband communications have entered into our everyday lives. This digital revolution has created a need for information systems security. With recent compliance laws requiring organizations to protect and secure private data and reduce liability, information systems security has never been more recognized than it is now.

Part II is adapted from CompTIA's Security+ professional certification. CompTIA's Security+ is the most widely accepted foundational, vendor-neutral IT security knowledge and skills professional certification. As a benchmark for foundational knowledge and best practices in IT security, the Security+ professional certification includes the essential principles for network security, operational security, and compliance. Also covering application, data, and host security, threats and vulnerabilities, access control, identity management, and cryptography, the Security+ certification provides a solid foundation for an IT security career.

Part III of this text provides a resource for readers and students desiring more information on information security standards, education, professional certifications, and recent compliance laws. These resources are ideal for students and individuals desiring additional information about educational and career opportunities in information systems security.

New to This Edition

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New to This Edition

This new edition has been updated to reflect the security environments you will encounter in today's organizations. The content has been slightly reorganized, extended, and refreshed to ensure that it covers the latest trends, standards, and industry best practices. Part I, The Need for Information

Security, covers how today's complex business environments have changed due to technological and cultural influences and how those changes impact security. Part II, Securing Today's Information Systems, continues the discussion from Part I to form the core material of the text. In Part II we dig into the various aspects and domains of cybersecurity and discuss how security applies in each case. This edition retains the technical information from previous editions but frames discussions in the context of satisfying business goals at the strategic level. Additional focus is placed on continuity and emerging strategic concerns. And, finally, Part III, Information Security Standards, Certifications, and Laws, presents an up-to-date overview of various external governance influences that inform security-related decisions and strategy. This latest edition provides the most comprehensive coverage to date of how to implement enterprise security as a strategic organizational objective.

Cloud Labs

This text is accompanied by Cybersecurity Cloud Labs. These hands-on virtual labs provide immersive mock IT infrastructures where students can learn and practice foundational cybersecurity skills as an extension of the lessons in this text. For more information or to purchase the labs, visit go.jblearning.com/Kim4e.

Learning Features

The writing style of this text is practical and conversational. Step-by-step examples of information security concepts and procedures are presented throughout the text. Each chapter begins with a statement of learning objectives. Illustrations are used to clarify the material and vary the presentation. The text is sprinkled with Notes, Tips, FYIs, Warnings, and Sidebars to alert the reader to additional helpful information related to the subject under discussion. Chapter assessments appear at the end of each chapter, with solutions provided in the back of the text.

Chapter summaries are included in the text to provide a rapid review or preview of the material and to help students understand the relative importance of the concepts presented.

Audience

The material is suitable for undergraduate or graduate computer science majors or information science majors, students at a two-year technical college or community college who have a basic technical background, or readers who have a basic understanding of IT security and want to expand their knowledge.

Acknowledgments

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I would like to thank Michael Solomon, for taking the lead authoring role on this fourth edition, and to the Jones & Bartlett Learning team led by Ned Hinman. This journey that we have been on together from the first to the fourth edition has allowed us to significantly impact the lives of new cybersecurity professionals across the country as well as protect our information assets.

This fourth edition book project commenced during the COVID-19 pandemic, which prevented me from being able to physically visit and spend quality time with my mom, Mrs. Yum Kim.

I would like to thank my mom for her unconditional love and for guiding me into the man I have become.

David Kim

I would like to thank David Kim and the whole Jones & Bartlett Learning team for providing pertinent editorial comments and for helping to fine-tune the book's content. All of you made the process so much easier and added a tremendous amount of value to the book. I want to thank God for blessing me so richly with such a wonderful family, and for my family's support throughout the years. My best friend and wife of over three decades, Stacey, is my biggest cheerleader and supporter through many professional and academic endeavors. I would not be who I am without her.

Both of our sons have always been sources of support and inspiration. To Noah, who still challenges me, keeps me sharp, and tries to keep me relevant, and Isaac, who left us far too early. We miss you, son.

Michael G. Solomon

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PART I
The Need for Information Security

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CHAPTER 1 Information Systems Security
CHAPTER 2 Emerging Technologies Are Changing How We Live
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CHAPTER 1
Information Systems Security

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THE WORLDWIDE NETWORK WE KNOW AS THE INTERNET HAS DEMONSTRATED phenomenal growth and change from its humble beginnings. Once merely a tool used by a small number of universities and government agencies, it is truly a global network with 5 billion users. As it has grown, it has changed the way people, and even devices, communicate and do business, creating untold opportunities and benefits. Today, the Internet continues to grow and expand in new and varied ways. It supports innovation and new services, such as real-time streaming and cloud computing. When the Internet started, the majority of connected devices were computers, whether for personal use or within a company. In the most recent years, however, an increasing variety of devices beyond computers, including smartphones, tablets, vehicles, appliances, doorbells, vending machines, drones, smart homes, and smart buildings, can connect and share data.

The Internet as we know it today is experiencing a growth spurt as the **Internet of Things (IoT)** spreads and impacts our daily lives. Although the Internet officially started in 1969, the extent to which people have come to depend on it is new. Today, people interact with the Internet and cyberspace as part of normal day-to-day living. In fact, not being connected to the Internet is often seen as annoying for both personal and business use. Users now face privacy and security issues regarding their personal and business information as intelligent and aggressive cybercriminals, terrorists, and scam artists increasingly and continuously lurk in the virtual shadows. Connecting computers and devices to the Internet immediately exposes them to attack, from which frustration and hardship can result. Anyone whose personal information has been stolen (called **identity theft**) can attest to that. Worse, attacks on computers and networked devices are a threat to the national economy, which depends on **e-commerce**. Even more important,

cyberattacks threaten national security; for example, terrorist attackers could shut down electricity grids or disrupt military communication.

You can make a difference. The world needs people who understand cybersecurity and can protect computers, devices, and networks from cybercriminals. Remember, it's all about protecting sensitive data and the infrastructure around it. To get you started, this chapter gives an overview of information systems security concepts and terms that you must understand to stop cyberattacks.

Chapter 1 Topics

This chapter covers the following topics and concepts:

- What unauthorized access and data breaches are
- What information systems security is
- What the tenets of information systems security are
- What the seven domains of an information technology (IT) infrastructure are
- What the weakest link in an IT infrastructure is
- How an IT security policy framework can reduce risk
- How a data classification standard affects an IT infrastructure's security needs

Chapter 1 Goals

When you complete this chapter, you will be able to:

- Describe how unauthorized access can lead to a data breach
- Relate how availability, integrity, and confidentiality requirements affect the seven domains of a typical IT infrastructure
- Describe the risk, threats, and vulnerabilities commonly found within the seven domains
- Identify a layered security approach throughout the seven domains

- Develop an IT security policy framework to help reduce risk from common threats and vulnerabilities
- Relate how a data classification standard affects the seven domains

Information Systems Security

Today's **Internet** is a worldwide network with approximately 5 billion users. It includes almost every government, business, and organization on Earth. However, having that many users on the same network wouldn't solely have been enough to make the Internet a game-changing innovation. These users needed some type of mechanism to locate documents and resources on different computers and link them together across a set of connected networks. In other words, a user on computer A needed an easy way to open a document on computer B. This need gave rise to a system that defines how documents and resources are related across a network of computers. The name of this system is the **World Wide Web (WWW)**, which is also known as **cyberspace** or simply the web. Think of it this way: The Internet links communication networks to one another; the web is the connection of websites, webpages, and digital content on those networked computers; and cyberspace is all the accessible users, networks, webpages, and applications working in this worldwide electronic realm.

Recent Data Breaches in the United States (2014–2020)

Each year the number of reported data breaches around the world grows, along with the damage they cause individuals and organizations. Both the public and the private sectors have fallen victim. **TABLE 1-1** lists a summary of recent data breaches, the affected organization, and the impact of the data breach to that organization.

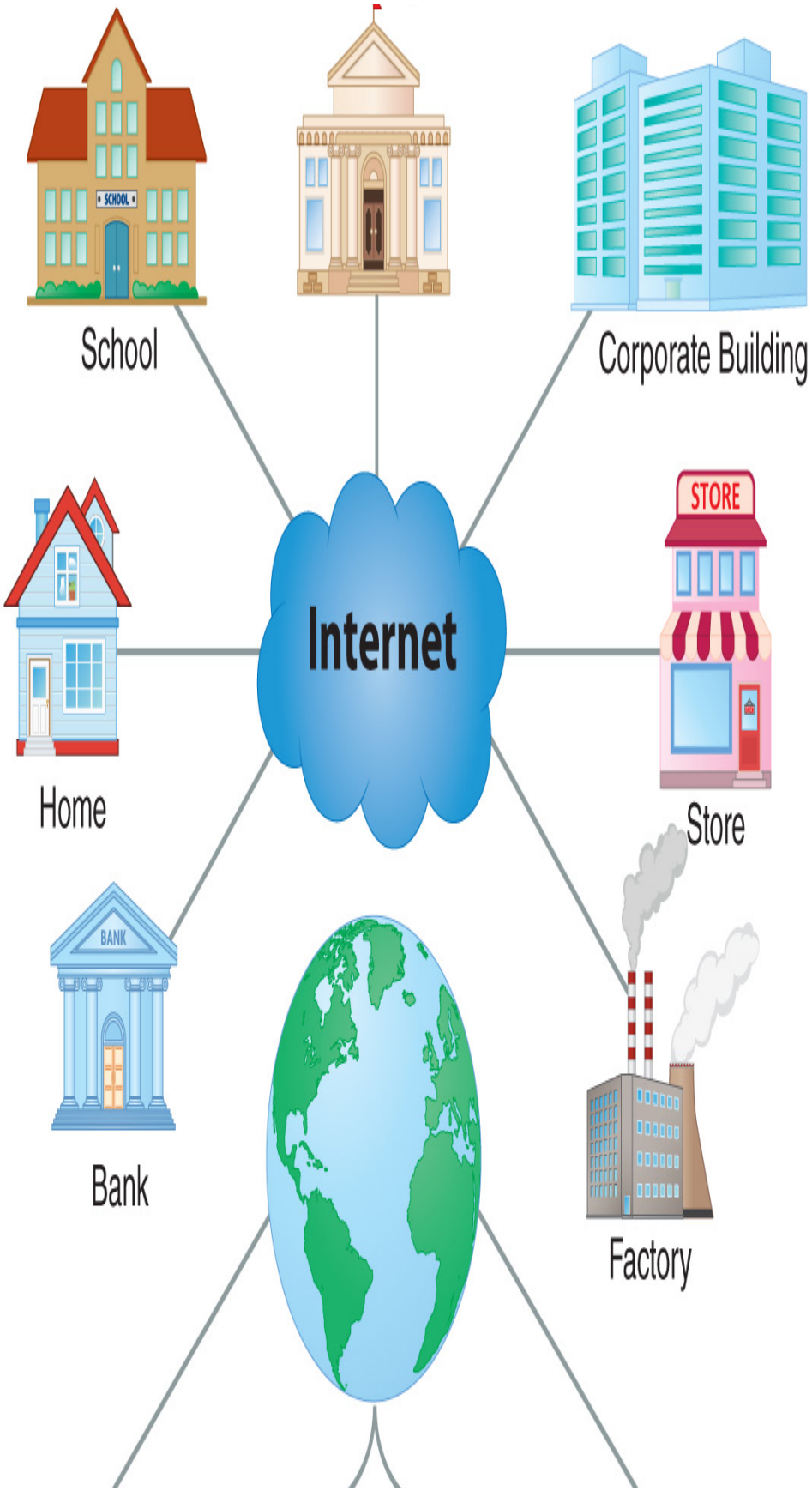
TABLE 1-1	Recent data breaches.

ORGANIZATION	DATA BREACH	IMPACT OF DATA BREACH
Yahoo	Yahoo disclosed in December 2016 that a group of hackers compromised 1 billion accounts. In October 2017, Yahoo released more information and increased the estimate of breached accounts to 3 billion.	As a result of the Yahoo breach, all Yahoo users were urged to change their passwords and update related security questions. Users were also discouraged from reusing passwords and to immediately change any passwords of other accounts that shared the disclosed Yahoo passwords.
First American Financial Corporation	About 885 million users had sensitive personal financial data leaked in May 2019. Hackers were able to extract data that included transactions dating back to 2003.	Customers were immediately at a higher risk of identity theft because their personal financial data had been breached, and that risk continues.
Verifications.io	In February 2019, 763 million unique user email addresses of the Verifications.io validation service were leaked along with names, telephone numbers, Internet Protocol (IP) addresses, birthdates, and gender.	As with the First American breach, Verifications.io customers were (and still are) exposed to an elevated risk of becoming a victim of identity theft.
Marriott/Starwood Hotels	The Starwood Hotels and Resorts information system was compromised in 2014, but the breach wasn't detected until 2018. The hackers silently collected customer data for four years. In the end, Starwood estimated that 500 million guests had personal information stolen, including passport information and payment card numbers for as many as 100 million customers, although payment card information was encrypted.	Two years before the Starwood breach was discovered, Marriott International acquired Starwood. Marriott had to deal with the largescale loss of customer confidence and was forced to invest an undisclosed amount to reassure its customers of its privacy and security policies.

Twitter	In May 2018, the Twitter social media platform announced that a software bug had resulted in user passwords being stored in an unencrypted log file location, making them accessible to hackers. Twitter strongly recommended that all 300 million users change their passwords but never disclosed how many accounts were actually affected by the breach.	Because many social media users use the same passwords on multiple sites, a password disclosure on one site could allow hackers to compromise accounts on multiple sites. Even with good password practices, a social media breach can disclose personal information that can be used for additional attacks, including identity theft.
FireEye	In December 2020, security firm FireEye announced its penetration testing tools, used to assess clients' data security, were stolen.	Given the purpose of FireEye's proprietary tools, FireEye warned that its tools could be used to maliciously hack into other companies.

Unfortunately, when you connect to cyberspace, you also open the door to a lot of bad actors who want to find and steal your data. Every computer or device that connects to the Internet is at risk, creating an IoT, which supports users in all aspects of their lives. Like outer space, the maturing Internet is a new frontier, and it has no Internet government or central authority. It is full of opportunities and challenges—and questionable behavior. Across the globe, public and private sectors have been compromised through unauthorized access and data breach attacks. These recent attacks have been committed by individuals, organized cybercriminals, and attackers working on behalf of other nations. The quantity of cyberattacks on national interests is increasing.

With the IoT now connecting personal and home devices, as well as vehicles, to the Internet, even more data is available to steal, making it imperative for all users to defend their information from attackers. **Cybersecurity** is the duty of every government that wants to ensure its national security, data security is the responsibility of every organization that needs to protect its information assets and sensitive data (e.g., Social Security and credit card numbers), and protection of our own data is the responsibility of all of us. **FIGURE 1-1** illustrates this new frontier.


SCHOOL
School
Corporate Building
Internet
STORE
Home
Store
BANK
Bank
Factory

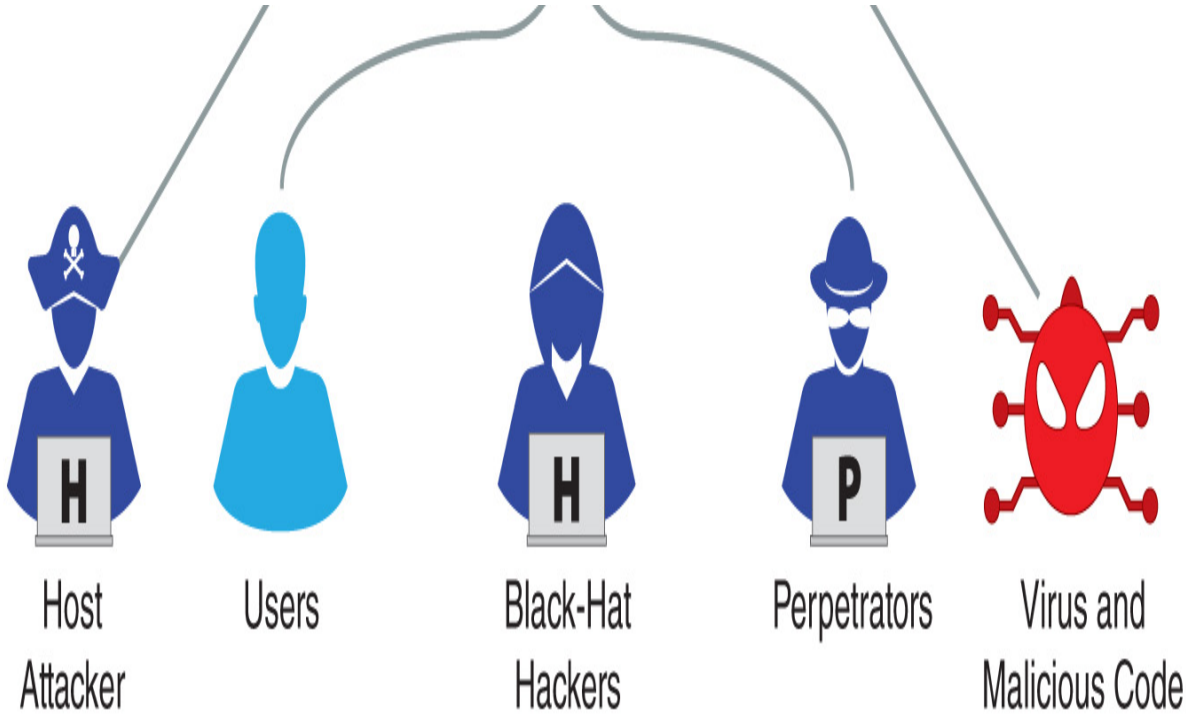
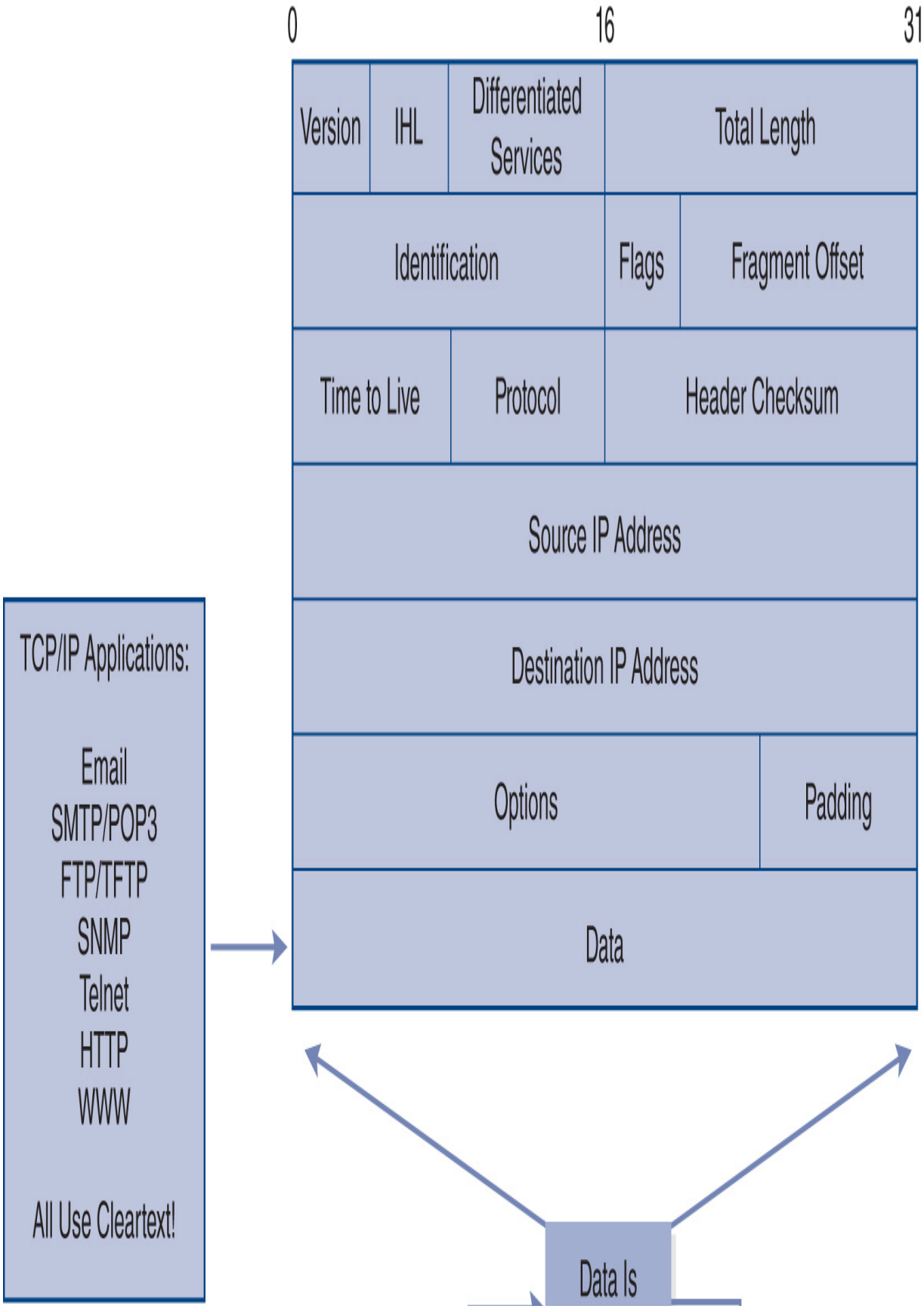


FIGURE 1-1 Cyberspace: The new frontier

The components that make up cyberspace are not automatically secure. Such components include cabling, physical networking devices, operating systems, and software applications that computers use to connect to the Internet. At the heart of the problem is the lack of security in the most common version of the communications **protocol** (i.e., a list of rules and methods for communicating across the Internet)—the **Transmission Control Protocol/Internet Protocol (TCP/IP)**. TCP/IP is not just one protocol but rather a suite of protocols developed for communicating across a network. Named after the two most important protocols, TCP/IP protocols work together to allow any two computers to be connected, in order to communicate, and thus create a network. TCP/IP breaks messages into chunks, or packets, to send data between networked computers. The data security problem lies in the fact that the data is readable within each IP packet, using simple software available to anyone. This readable mode is known as **cleartext**. That means the data sent inside a TCP/IP packet must be hidden or encrypted to make the data more secure. **FIGURE 1-2** shows the data within the TCP/IP packet structure.


0
16
31
Version
IHL
Differentiated Services
Total Length
Identification
Flags
Fragment Offset
Time to Live
Protocol
Header Checksum
Source IP Address
Destination IP Address
Options
Padding
Data
TCP/IP Applications:
Email
SMTP/POP3
FTP/TFTP
SNMP
Telnet
HTTP
WWW
All Use Cleartext!
Data Is

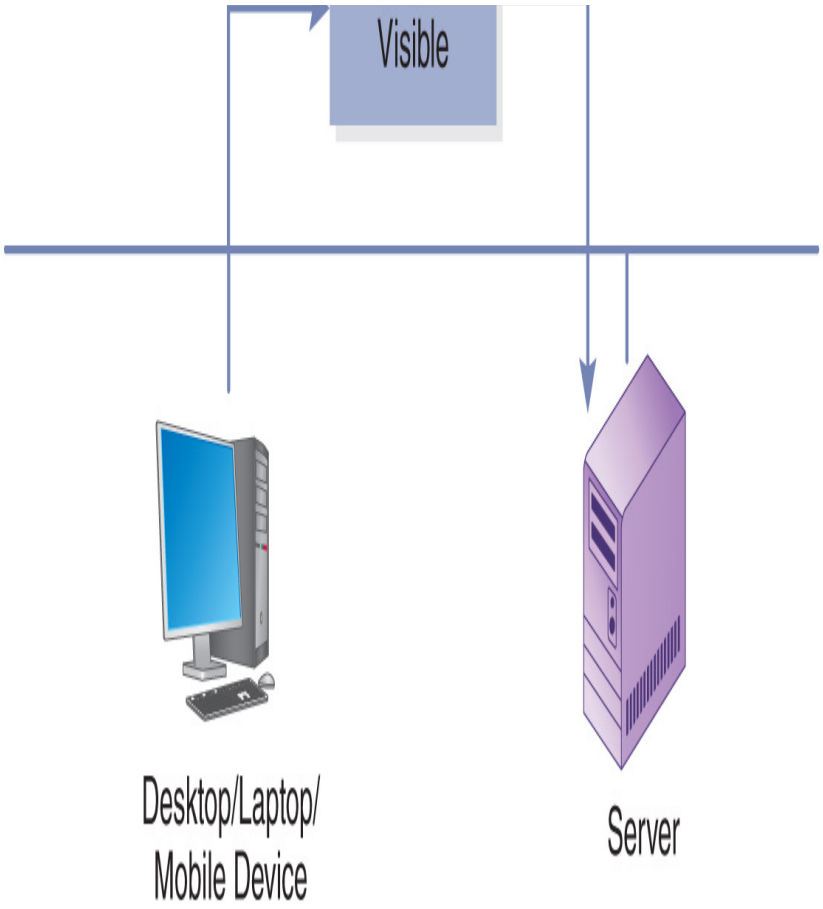


FIGURE 1-2 TCP/IP communications are in cleartext

All this raises the question, if the Internet is so unsafe, why does everyone connect to it so willingly and add to its growth? The answer is the huge growth of the web from the mid-1990s to the early 2000s and the relatively low perceived risk of getting online. Connecting to the Internet gave anyone instant access to the web and its many resources. In the early years of the web, cybercrime was rare, and most users felt safe and anonymous online. The appeal of easy, worldwide connectivity drove the demand to connect. This demand and subsequent growth helped drive costs lower for high-speed communications. Households, businesses, and governments gained affordable high-speed Internet access, and, as wireless and cellular connections have become more common and affordable, staying connected has become easier no matter where you are and what devices you need to connect. **FIGURE 1-3** shows how the IoT is making the world digitally connected. The IoT

magnifies the risk, threat, and vulnerability issues, given that a hacker or an attacker can gain unauthorized access to any IP-connected device. Once access to an IP-connected device has been granted, data can be stolen or damage done if the attacker so desires. This “dark villain” nature of a hacker is what helped label hackers as “black hats.”

FIGURE 1-3 Internet of Things (IoT) supports any-to-any connectivity

Internet growth has also been driven by generational differences. The Generation Y (people born between 1981 and 1996, also called Millennials) culture came into prominence as baby boomers began to retire. This new generation of people grew up with cell phones, **smartphones**, and increasingly available Internet access. There is even a newer named generation, Generation Z (people born between 1997 and 2012), who have never known a life without smartphones and nearly constant connectivity and real-time communication. Today's personal communications include Voice over Internet Protocol (VoIP), text messaging, and social media as well as audio conferencing and video conferencing. These real-time Session Initiation Protocol–enabled (SIP-enabled) applications are commonly known as **unified communications**. Examples of unified communication applications include Google Chat™ instant messaging service, Yahoo!®

Messenger, Webex™, GoToMeeting™, Zoom™, Adobe Connect™, and Skype™ for Business's online meeting features.

Meanwhile, an **information security** war is raging. The battlefield is cyberspace, and the enemies are already within the gates. To make matters worse, the enemy is everywhere—in the local area and around the world—and seeks sensitive data. Thus, the name of the game for an attacker is to gain unauthorized access, which means that the attacker obtains users' authorized logon IDs and passwords without their permission. Using those logon credentials, the attacker gains access to all the systems and applications that the users' access permits. If unauthorized access is granted, then sensitive data may be accessible and can be downloaded, depending on that user's access controls. For this reason, IT infrastructures need proper security controls. Because of the information security war, a great demand has been created for information systems security and information assurance professionals, who represent a new kind of cyberwarrior to help defend security and business interests.

Risks, Threats, and Vulnerabilities

This text introduces the dangers of cyberspace and discusses how to address those dangers. It explains how to identify and combat the dangers common in **information systems** and IT infrastructures. To understand how to make computers as secure as possible, first, you first need to understand the concepts of risks, threats, and vulnerabilities.

Risk is the level of exposure to some event that has an effect on an asset, usually the likelihood that something bad will happen to an asset. In the context of IT security, an asset can be a computer, a device, a database, or a piece of information. Examples of risk include the following:

- Losing access to data
- Losing business because a disaster has destroyed the building in which the business operates
- Failing to comply with laws and regulations

A **threat** is any action, either natural or human induced, that could damage an asset. Natural threats include floods, earthquakes, and severe storms, all

of which require organizations to create plans to ensure that business operations can continue (i.e., a business continuity plan [BCP]) and the organization can recover (i.e., disaster recovery plan [DRP]). A BCP prioritizes the functions an organization needs to keep going, and a DRP defines how a business gets back on its feet after a major disaster, such as a fire or hurricane. Human-caused threats to a computer system include viruses, malicious code, and unauthorized access. A virus is a computer program written to cause damage to a system, an application, or data, and malicious code, or malware, is a computer program written to cause a specific action to occur, such as erasing a hard drive. Threats can harm an individual, a business, or an organization.

A **vulnerability** is a weakness that allows a threat to be realized or to have an effect on an asset. To understand what a vulnerability is, think about lighting a fire. On the one hand, if you were cooking a meal on a grill, you would need to light a fire in the grill, which is designed to contain the fire so that the fire poses no danger if the grill is used properly. On the other hand, lighting a fire in a computer data center will likely cause damage because a computer data center is vulnerable to fire, whereas a grill is not. Therefore, a threat by itself does not always cause damage; there must be a *vulnerability* for a threat to be realized.

Vulnerabilities can often result in legal liabilities. Because computers must run software to be useful and humans write software, software programs inevitably contain errors. Thus, software vendors must protect themselves from the liabilities of their own vulnerabilities with an **End-User License Agreement (EULA)**. A EULA takes effect when the user installs the software. All software vendors use EULAs, which means that the burden of protecting IT systems and data lies with internal information systems security professionals.

End-User License Agreements (EULAs)

EULAs are license agreements between a user and a software vendor. EULAs are used to protect software vendors from claims arising from the behavior of imperfect software and typically contain a warranty disclaimer, which limits the vendors' liability from software bugs and weaknesses that hackers can exploit.

Here is an excerpt from Microsoft's EULA, stating that the company offers only "limited" warranties for its software. The EULA also advises that the software product is offered "as is and with all faults."

DISCLAIMER OF WARRANTIES. THE LIMITED WARRANTY THAT APPEARS ABOVE IS THE ONLY EXPRESS WARRANTY MADE TO YOU AND IS PROVIDED IN LIEU OF ANY OTHER EXPRESS WARRANTIES (IF ANY) CREATED BY ANY DOCUMENTATION OR PACKAGING. EXCEPT FOR THE LIMITED WARRANTY AND TO THE MAXIMUM EXTENT PERMITTED BY APPLICABLE LAW, MICROSOFT AND ITS SUPPLIERS PROVIDE THE SOFTWARE PRODUCT AND SUPPORT SERVICES (IF ANY) AS IS AND WITH ALL FAULTS, AND HEREBY DISCLAIM ALL OTHER WARRANTIES AND CONDITIONS.

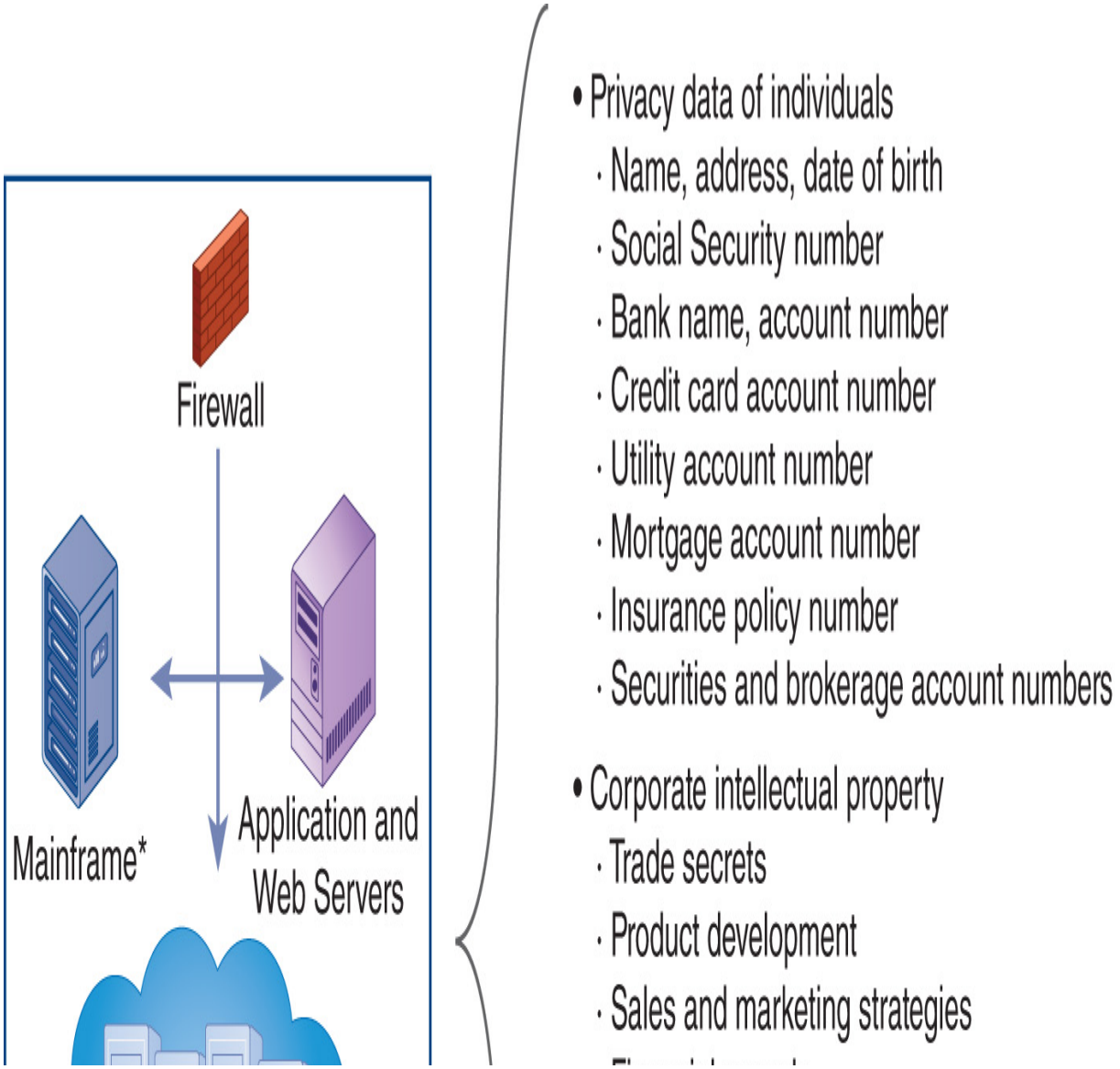
Microsoft's EULA also limits its financial liability to the cost of the software or $5 (U.S.), whichever is greater:

LIMITATION OF LIABILITY. ANY REMEDIES NOTWITHSTANDING ANY DAMAGES THAT YOU MIGHT INCUR FOR ANY REASON WHATSOEVER (INCLUDING, WITHOUT LIMITATION, ALL DAMAGES REFERENCED ABOVE AND ALL DIRECT OR GENERAL DAMAGES), THE ENTIRE LIABILITY OF MICROSOFT AND ANY OF ITS SUPPLIERS UNDER ANY PROVISION OF THIS EULA AND YOUR EXCLUSIVE REMEDY FOR ALL OF THE FOREGOING (EXCEPT FOR ANY REMEDY OF REPAIR OR REPLACEMENT ELECTED BY MICROSOFT WITH RESPECT TO ANY BREACH OF THE LIMITED WARRANTY) SHALL BE LIMITED TO THE GREATER OF THE AMOUNT ACTUALLY PAID BY YOU FOR THE SOFTWARE PRODUCT OR U.S.$5.00. THE FOREGOING LIMITATIONS, EXCLUSIONS AND DISCLAIMERS (INCLUDING SECTIONS 9, 10 AND 11 ABOVE) SHALL APPLY TO THE MAXIMUM EXTENT PERMITTED BY APPLICABLE LAW, EVEN IF ANY REMEDY FAILS ITS ESSENTIAL PURPOSE.

Used with permission from Microsoft.

What Is Information Systems Security?

The easiest way to define information systems security is to break it into its component parts. An information system consists of the hardware, operating system, and application software that work together to collect, process, and store data for individuals and organizations. ***Security*** is being free from danger or risk. Since there is always some amount of risk present, achieving security is aspirational, not absolute. Thus, **information systems security** is the collection of activities that protect the information system and the data stored in it. Many U.S. and international laws now require this kind of security assurance, and organizations must address this need head-on. **FIGURE 1-4** reviews the types of information commonly found within an IT infrastructure.


Firewall
Mainframe*
Application and Web Servers
• Privacy data of individuals
· Name, address, date of birth
· Social Security number
· Bank name, account number
· Credit card account number
· Utility account number
· Mortgage account number
· Insurance policy number
· Securities and brokerage account numbers
• Corporate intellectual property
· Trade secrets
· Product development
· Sales and marketing strategies

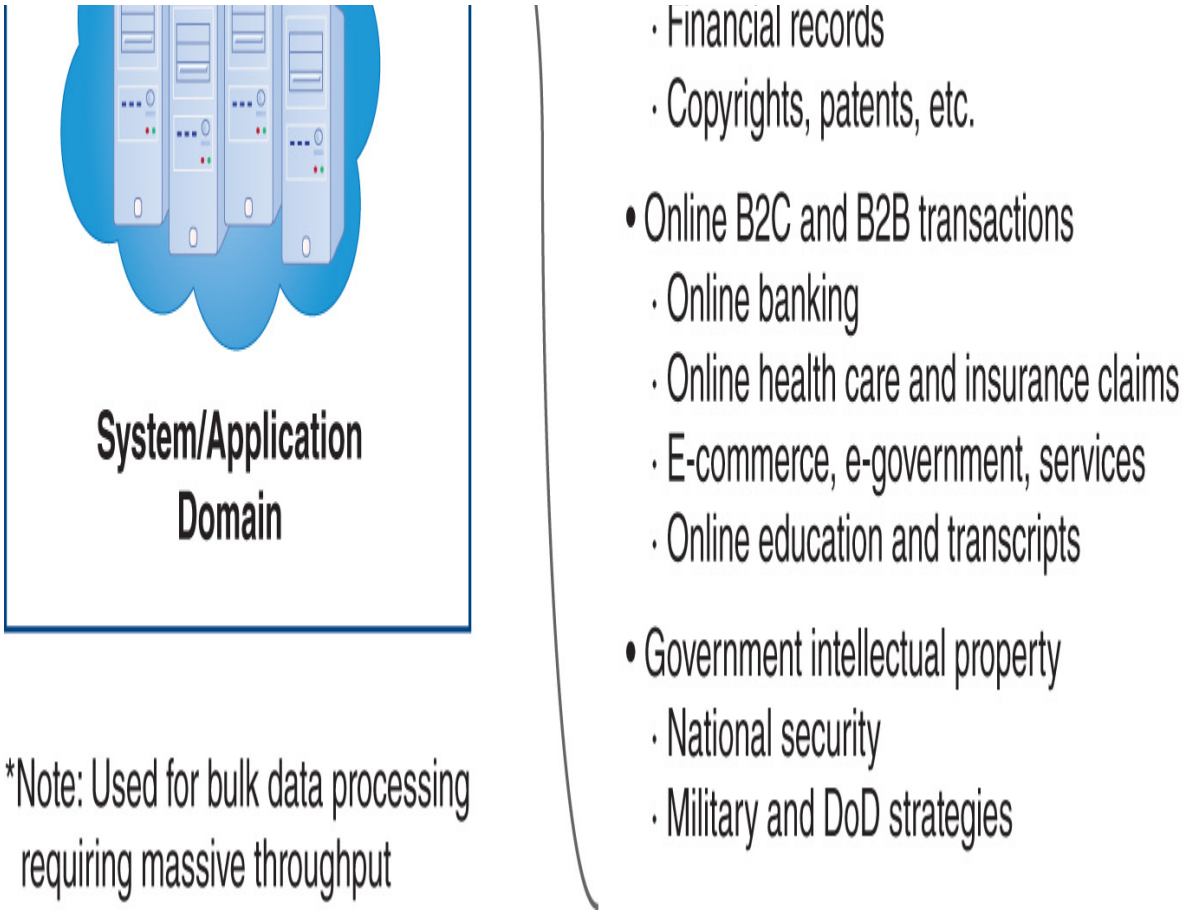

System/Application Domain
*Note: Used for bulk data processing requiring massive throughput
· Financial records
· Copyrights, patents, etc.
• Online B2C and B2B transactions
· Online banking
· Online health care and insurance claims
· E-commerce, e-government, services
· Online education and transcripts
• Government intellectual property
· National security
· Military and DoD strategies

FIGURE 1-4 What are we securing?

Compliance Laws and Regulations Drive the Need for Information Systems Security

Cyberspace brings new threats to people and organizations. Individuals need to protect their privacy, and businesses and organizations are responsible for protecting both their intellectual property and any personal or private data they handle. Various laws require organizations to use security controls to protect private and confidential data. Current laws and regulations related to information security include the following:

- **Federal Information Security Management Act (FISMA)**—Passed in 2002, FISMA requires federal civilian agencies to provide security controls over resources that support federal operations.

- **Federal Information Security Modernization Act (FISMA)**—Passed in 2014, FISMA was enacted to update FISMA 2002 with information on modern threats as well as security controls and best practices.
- **Sarbanes-Oxley Act (SOX)**—Passed in 2002, SOX requires publicly traded companies to submit accurate and reliable financial reporting. This law does not require securing private information, but it does require security controls to protect the confidentiality and integrity of the reporting itself.
- **Gramm-Leach-Bliley Act (GLBA)**—Passed in 1999, GLBA requires all types of financial institutions to protect customers' private financial information.
- **Health Insurance Portability and Accountability Act (HIPAA)**—Passed in 1996, HIPAA requires health care organizations to implement security and privacy controls to ensure patient privacy.
- **Children's Internet Protection Act (CIPA)**—Passed in 2000 and updated in 2011, CIPA requires public schools and public libraries to use an Internet safety policy. The policy must address the following:
    - Restricting children's access to inappropriate matter on the Internet
    - Ensuring children's security when they are using email, chatrooms, and other electronic communications
    - Restricting hacking and other unlawful activities by children online
    - Prohibiting the disclosure and distribution of personal information about children without permission
    - Restricting children's access to harmful materials
    - Warning children on the use and dangers of social media
- **Family Educational Rights and Privacy Act (FERPA)**—Passed in 1974, FERPA protects the private data of students and their school records.

FIGURE 1-5 shows these laws by industry.

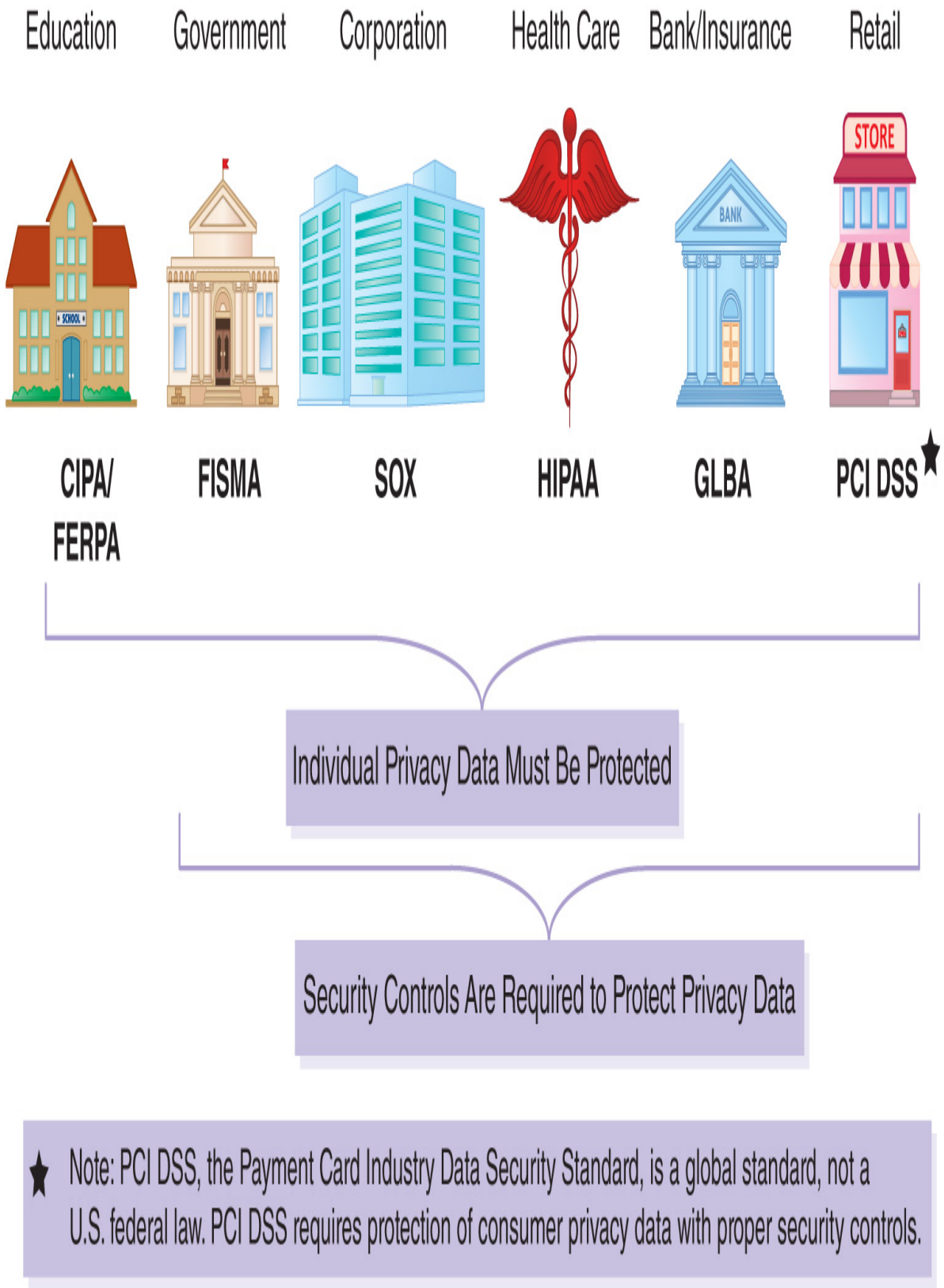


FIGURE 1-5 Compliance laws and regulations drive the need for information systems security

All of the compliance laws listed so far are U.S. laws, but the United States is not the only place legislators are concerned about security and privacy. Many nations are busy crafting laws and regulations to protect organizations and consumers from cybercriminals. One of the most recent and wide-ranging attempts to protect personal data privacy is the European Union's (EU's) **General Data Protection Regulation (GDPR)**. GDPR is a regulation in EU law that protects each EU citizen's individual data. GDPR gives individuals ownership of their personal data and limits how that data can be collected and used. Although GDPR is an EU regulation, it covers data that flows into and out of EU information systems. Any organization in the world that handles EU citizen data is required to comply with GDPR.

Tenets of Information Systems Security

Most people agree that private information should be secure, but what does "secure information" really mean? Information that is secure satisfies three tenets, or properties, of information. If you can ensure these three tenets, you satisfy the requirements of secure information. The three tenets are as follows

- **Confidentiality**—Only authorized users can view information.
- **Integrity**—Only authorized users can change information.
- **Availability**—Information is accessible by authorized users whenever they request the information.

Technical TIP

Some systems security professionals refer to the tenets as the A-I-C triad to avoid confusion with the U.S. Central Intelligence Agency, commonly known as the CIA. However, you'll most commonly see C-I-A in information security refer to the security triad, or tenets of security.

FIGURE 1-6 illustrates the three tenets of information systems security. When you design and use security controls, you are addressing one or more of these tenets.

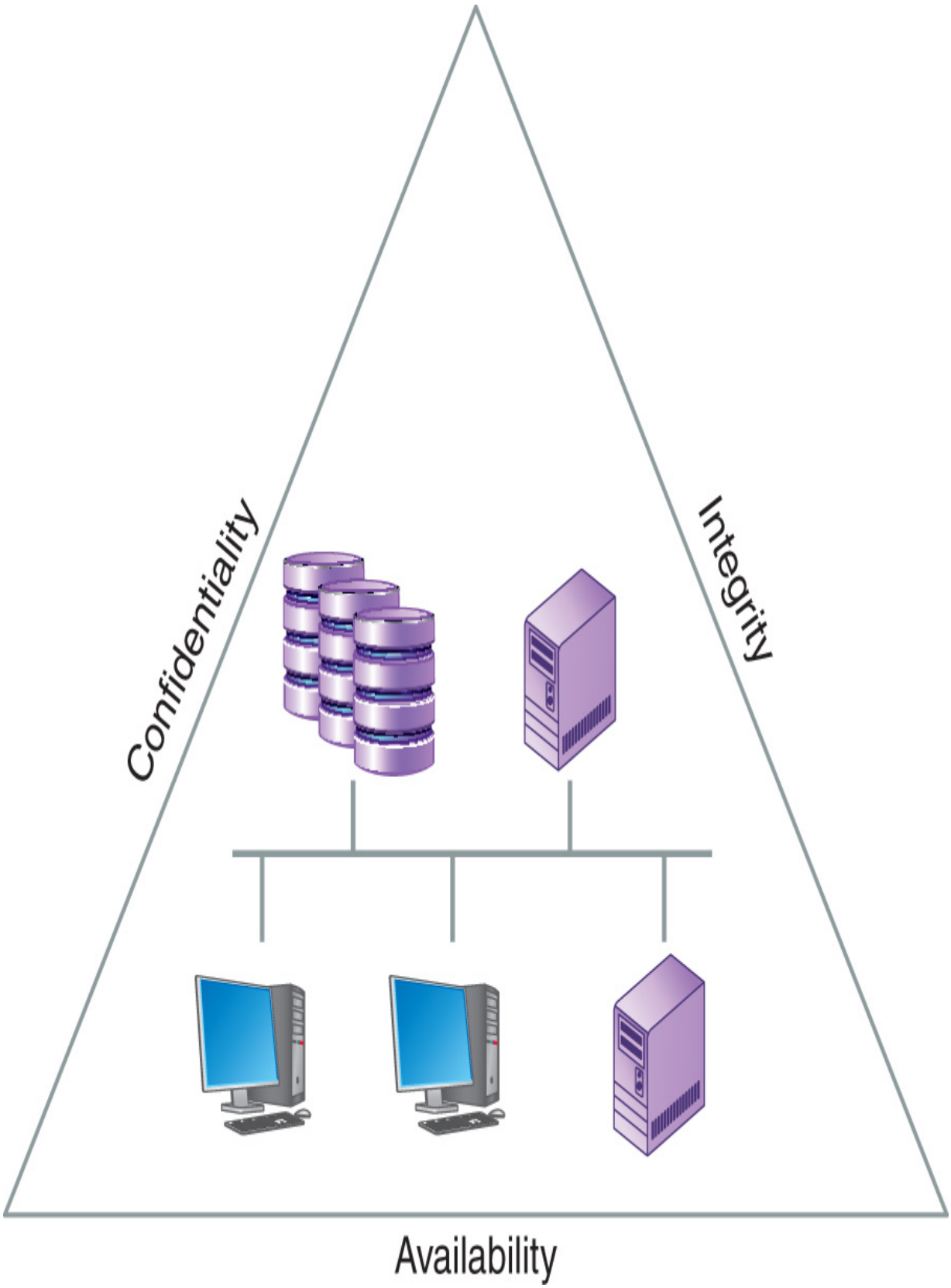


FIGURE 1-6 The three tenets of information systems security

When finding solutions to security issues, you must use the **confidentiality, integrity, and availability (C-I-A)** triad to define the organization's security baseline goals for a typical IT infrastructure. Once defined, these goals will translate into security controls and requirements based on the type of data being protected.

Identity Theft

Identity theft affects about 15 million U.S. citizens each year, with financial losses costing upward of $50 billion, and is a major threat to U.S. consumers. Many elements make up a person's identity, including but not limited to the following:

- Full name
- Mailing address
- Date of birth
- Social Security number
- Bank name
- Bank account number
- Credit card account number
- Utility account number
- Medical record number
- Mortgage account number
- Insurance policy number
- Securities and investment account numbers

For example, impostors can access people's accounts with just their name, home address, and Social Security number. Paper statements and account numbers tossed in the garbage can be retrieved by an unscrupulous person, making it easier for someone's private data and financial account information to be compromised. To reduce the possibility of loss, these documents should be shredded before they are discarded.

Identity theft extends beyond mere financial loss to damaging your Fair Isaac Corp. (**FICO**) personal credit rating, which could stop you from

getting a bank loan, mortgage, or credit card. It can take years to clean up your personal credit history. FICO is a publicly traded company that provides information used by Equifax, Experian, and TransUnion, the three largest consumer credit–reporting agencies in the United States.

Confidentiality

Confidentiality is a common term that means guarding information from everyone except those with rights to it. Confidential information includes the following:

- Private data of individuals
- Intellectual property of businesses
- National security for countries and governments

U.S. compliance laws that protect individuals' private data require businesses and organizations to have proper security controls to ensure confidentiality.

With the explosive growth in online commerce, more people are making online purchases with credit cards, which requires people to provide their private data to e-commerce websites; therefore, consumers should be careful to protect their personal identity and private data. Moreover, laws require organizations to use security controls to protect individuals' private data. A **security control** is a safeguard or countermeasure an organization implements to help reduce risk. Examples of such controls include the following:

- Conducting annual security awareness training for employees, which helps remind staff about proper handling of private data and drives awareness of the organization's framework of security policies, standards, procedures, and guidelines.
- Implementing an IT security policy framework, which is an outline that identifies where security controls should be used.
- Designing a layered security solution for an IT infrastructure. The more layers, or compartments, that block or protect private data and

intellectual property, the more difficult the data and property are to find and steal.

- Performing periodic security risk assessments, audits, and penetration tests on websites and IT infrastructure. Through performing these tasks, security professionals verify that they have properly installed the controls.
- Enabling security incident and event monitoring at the Internet entry and exit points, which is like using a microscope to see what is coming in and going out.
- Using automated workstation and server antivirus and malicious software protection, which helps to keep viruses and malicious software out of computers.
- Using more stringent access controls beyond a logon ID and password for sensitive systems, applications, and data. Access to more sensitive systems should have a second test to confirm the user's identity.
- Minimizing software weaknesses in computers and servers by updating them with patches and security fixes, which helps to keep the operating system and application software up to date.

Protecting private data is the process of ensuring data confidentiality. Organizations must use proper security controls specific to this concern, such as the following:

- Defining organization-wide policies, standards, procedures, and guidelines to protect confidential data, all of which provide guidance for how to handle private data.
- Adopting a **data classification standard** that defines how to treat data throughout the IT infrastructure, which is the road map for identifying what controls are needed to keep data safe.
- Limiting access to systems and applications that house confidential data to only those authorized to use that data.
- Using cryptography techniques to hide confidential data and keep it inaccessible to unauthorized users.
- Encrypting data that crosses the public Internet.
- Encrypting data that is stored within databases and storage devices.

Sending data to other computers, using a network, means that confidential data must be kept from unauthorized users, which entails the use of cryptography to make it unreadable. Thus, encryption is the process of transforming data from cleartext (i.e., data that anyone can read) into ciphertext (i.e., the scrambled data that results from encrypting cleartext). An example of this process is shown in **FIGURE 1-7**.

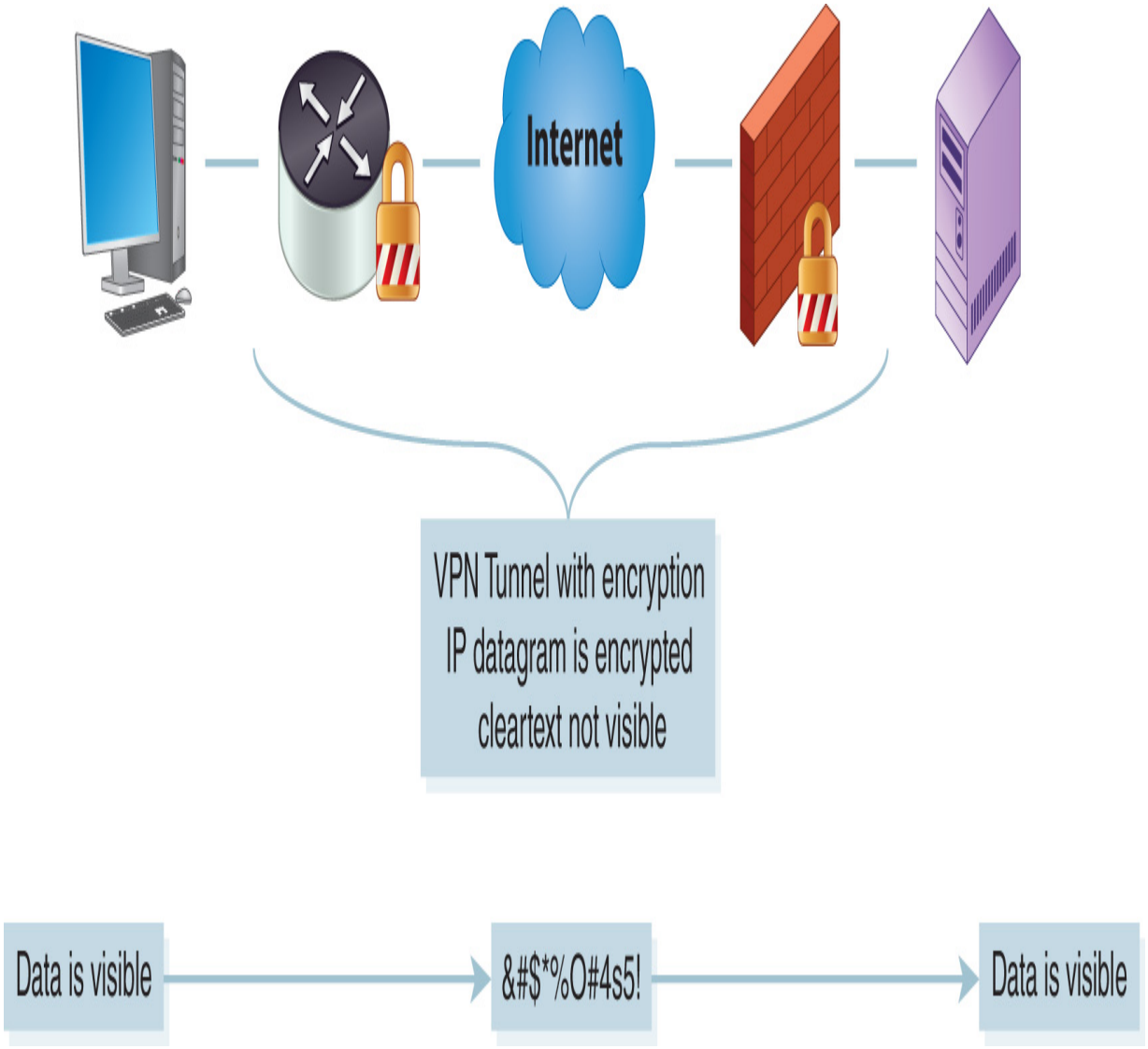
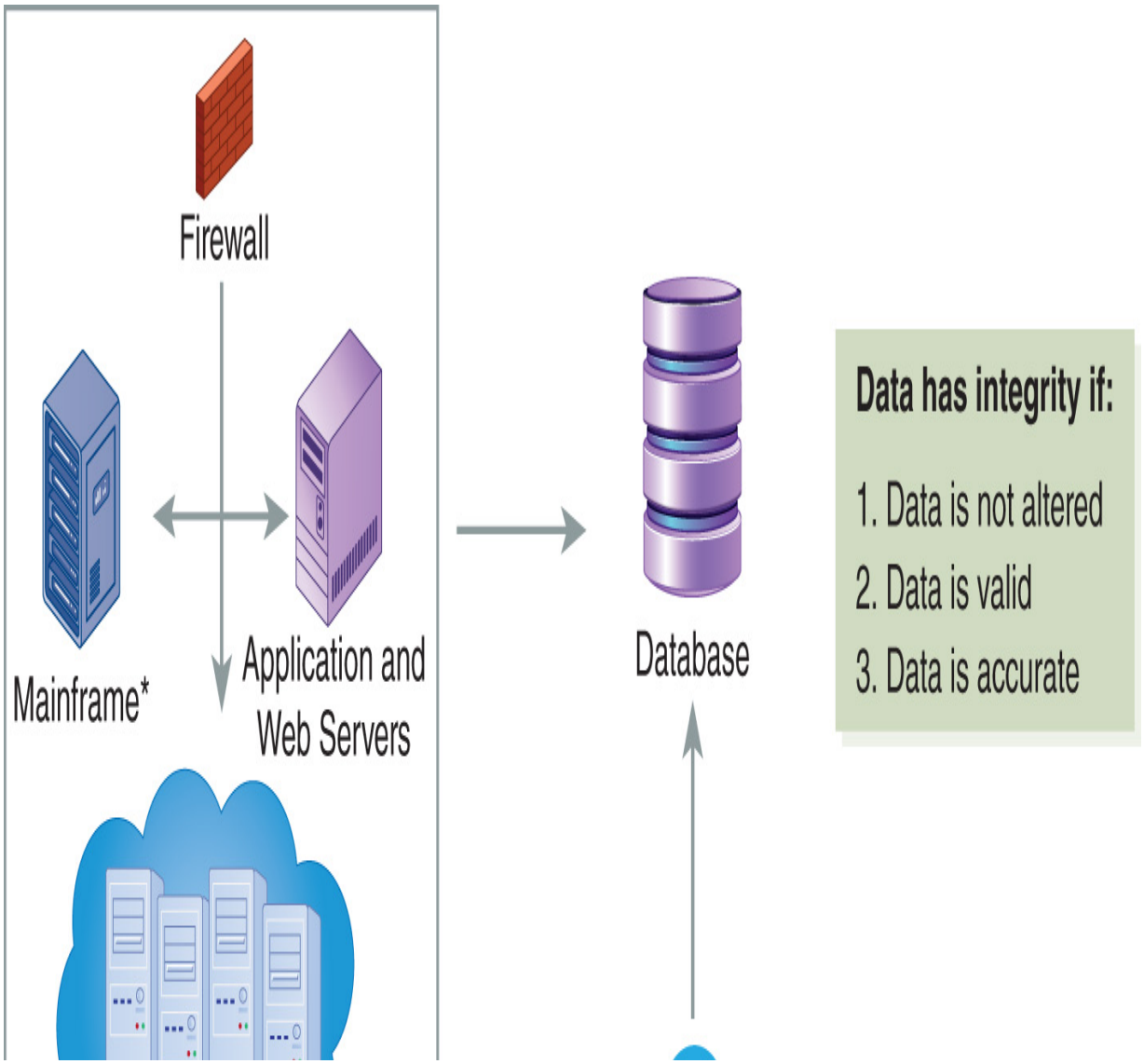


FIGURE 1-7 Encryption of cleartext into ciphertext

Data confidentiality and privacy are so important that local and state governments are passing and strengthening laws to protect it at the state and federal levels.

Integrity

Integrity deals with the validity and accuracy of data. Data lacking integrity —that is, data that is not accurate nor valid—is of no use. For some organizations, data and information are intellectual property assets, examples of which include copyrights, patents, secret formulas, and customer databases. This information can have great value, which unauthorized changes can undermine. For this reason, integrity is a tenet of systems security. **FIGURE 1-8** shows what is meant by data integrity and whether that data is usable. Sabotage and corruption of data integrity are serious threats to an organization, especially if the data is critical to business operations.



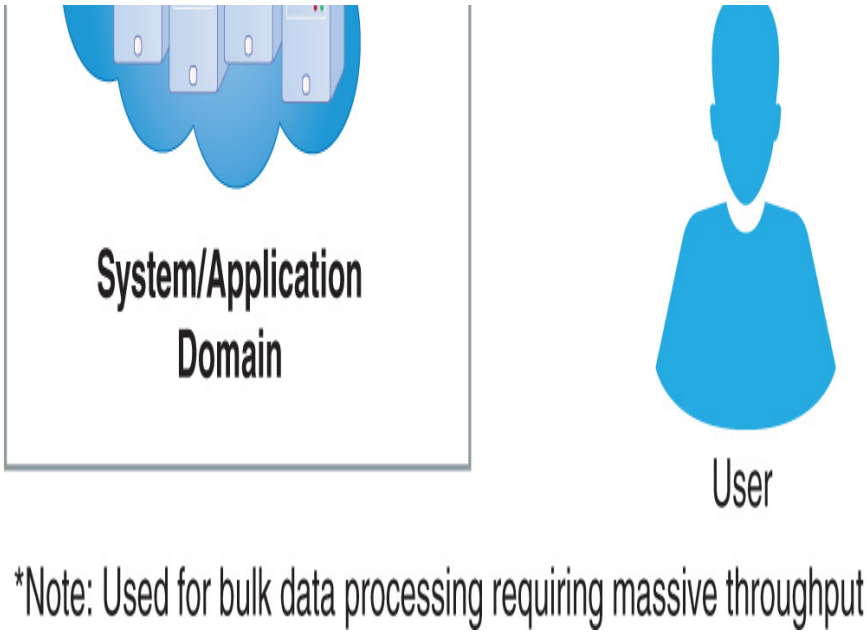


FIGURE 1-8 Data integrity

WARNING

Because email traffic transmits through the Internet in cleartext, which means it is completely visible to whomever sees the email, never enter private data in an email. Moreover, never enter private data in a website if that site is not a trusted host, which can be checked by telephone or other means, nor into a website or web application that does not use encryption (e.g., look for the lock icon in the computer's browser to verify whether **Hypertext Transfer Protocol Secure (HTTPS)** encryption is enabled on that website or application).

Availability

Availability is a common term in everyday life. For example, you probably pay attention to the availability of your Internet, TV, or cell phone service. In the context of information security, availability is generally expressed as the amount of time users can use a system, application, and data. Common availability time measurements include the following:

- **Uptime**—**Uptime** is the total amount of time that a system, application, and data are accessible. Uptime is typically measured in units of seconds, minutes, and hours within a given calendar month. Often, uptime is expressed as a percentage of time available (e.g., 99.5 percent uptime).
- **Downtime**—**Downtime** is the total amount of time that a system, application, and data are not accessible. Downtime also is measured in units of seconds, minutes, and hours for a calendar month.
- **Availability**—Availability is a mathematical calculation where A = (Total Uptime)/(Total Uptime + Total Downtime).
- **Mean time to failure (MTTF)**—MTTF is the average amount of time between failures for a particular system. Semiconductors and electronics do not break and, therefore, have an MTTF of many years (25 or more). Physical parts, such as connectors, cabling, fans, and power supplies, have a much lower MTTF (five years or less) given that wear and tear can break them.
- **Mean time to repair (MTTR)**—MTTR is the average amount of time it takes to repair a system, application, or component. The goal is to bring the system back up quickly.
- **Mean time between failures (MTBF)—**MTBF is the predicted amount of time between failures of an IT system during operation.
- **Recovery point objective (RPO)**—RPO is the amount of data that an organization can lose and still operate. A successful recovery operation recovers data such that the net loss is smaller than the RPO.
- **Recovery time objective (RTO)**—RTO is the amount of time it takes to recover and make a system, application, and data available for use after an outage. BCPs typically define an RTO for mission-critical systems, applications, and data access.

How to Calculate Monthly Availability

For a given 30-day calendar month, the total amount of uptime equals:

30 days × 24 hours/day × 60 minutes/hour = 43,200 minutes

For a 28-day calendar month (February), the total amount of uptime equals:

28 days × 24 hours/day × 60 minutes/hour = 40,320 minutes

Using the formula

Availability = (Total Uptime)/(Total Uptime + Total Downtime)

the availability factor for a 30-day calendar month with 30 minutes of scheduled downtime in that calendar month is calculated as:

Availability = (43,200 minutes)/(43,200 minutes + 30 minutes) = 0.9993, or 99.93%

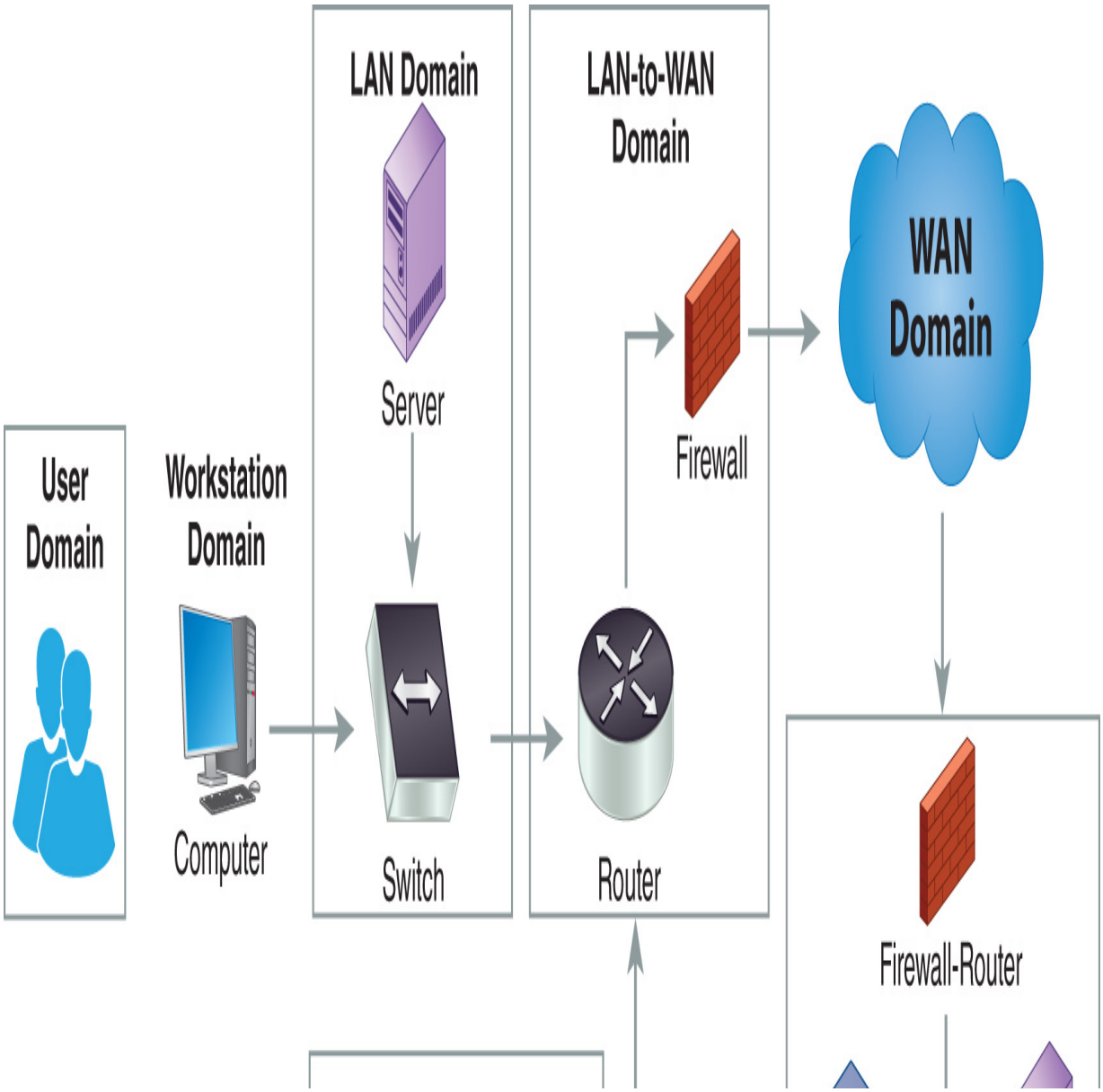
Telecommunications and Internet service providers offer their customers **service-level agreements (SLAs)**. An SLA is a contract that guarantees a minimum monthly availability of service for wide area network (WAN) and Internet access links. SLAs accompany WAN services and dedicated Internet access links. Availability measures a monthly uptime service-level commitment. As in the monthly availability example discussed in the sidebar, 30 minutes of downtime in a 30-day calendar month equates to 99.93 percent availability. Service providers typically offer SLAs ranging from 99.5 percent to 99.999 percent availability.

Technical TIP

Some systems security professionals refer to the tenets as the A-I-C triad to avoid confusion with the U.S. Central Intelligence Agency, commonly known as the CIA. However, you'll most commonly see C-I-A in information security refer to the security triad, or tenets of security.

The Seven Domains of a Typical IT Infrastructure

What role do the three tenets of systems security play in a typical IT infrastructure? First, let's review what a typical IT infrastructure looks like. Whether in a small business, large government body, or publicly traded corporation, most IT infrastructures consist of the seven domains shown in **FIGURE 1-9**: User, Workstation, LAN, LAN-to-WAN, WAN, Remote Access, and System/Application Domains.



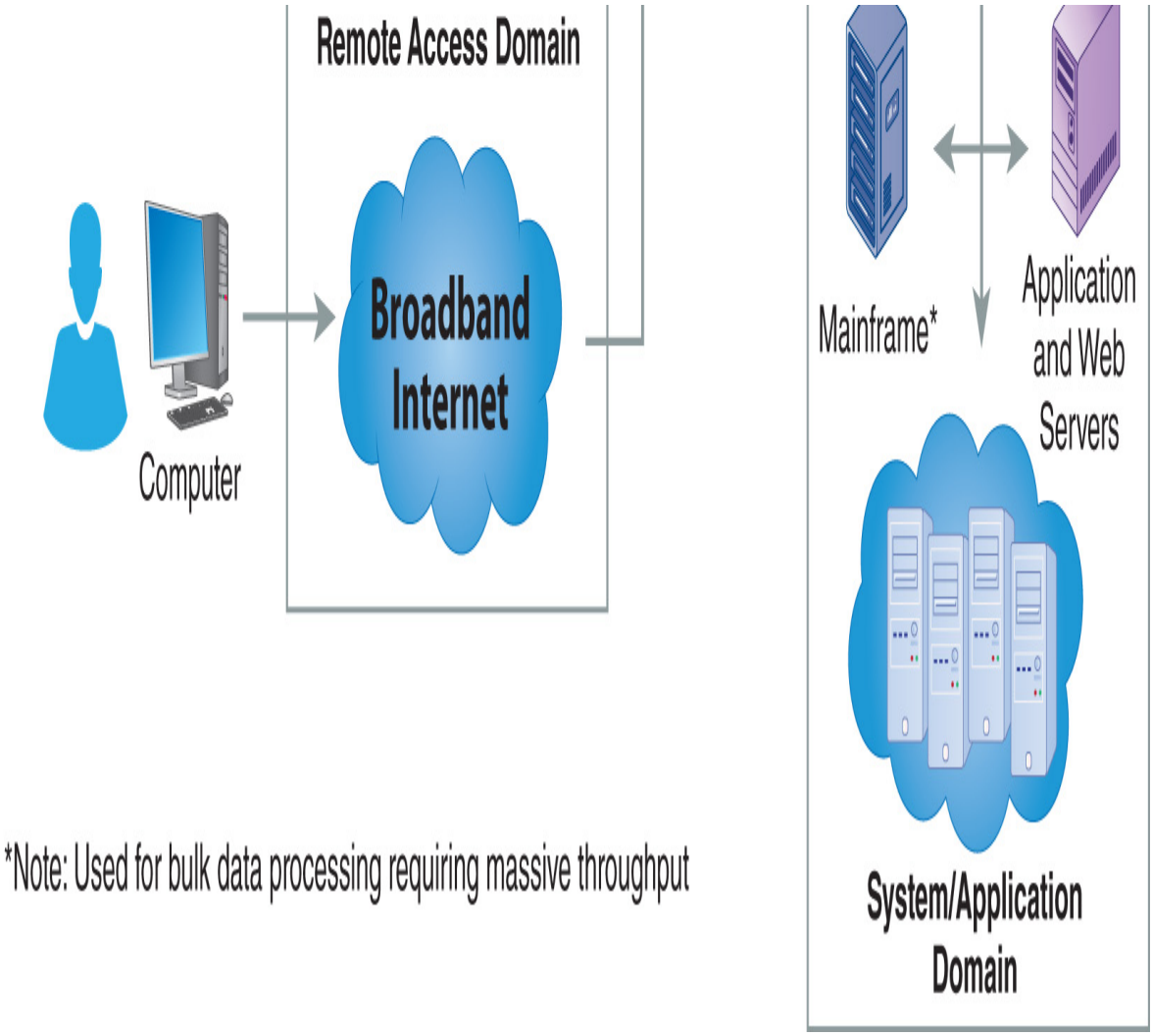


FIGURE 1-9 The seven domains of a typical IT infrastructure

Each domain requires proper security controls, which must meet the requirements of the C-I-A triad. Following is an overview of the seven domains and the risks, threats, and vulnerabilities commonly found in today's IT environments. Each domain may not be represented in every IT environment you encounter, but the infrastructure provides a good framework for discussing a strong, layered approach to security.

User Domain

The User Domain defines the people and processes that access an organization's information system.

User Domain Roles, Responsibilities, and Accountability

Following is an overview of what should go on in the User Domain:

- **Roles and tasks**—Users can access systems, applications, and data, depending on their defined access rights, and must conform to the staff manual and policies. An acceptable use policy (AUP), which is like a rule book for employees that defines what they are allowed and not allowed to do with organization-owned IT assets, will be found in this domain. Violation of these rules can be grounds for dismissal.
- **Responsibilities**—Employees are responsible for their use of IT assets. New legislation means that for most organizations it's a best practice to introduce an AUP. Organizations may require staff, contractors, or other third parties to sign an agreement to keep information confidential, and some organizations require a criminal background check for sensitive positions. The department or human resources manager is usually in charge of making sure employees sign and follow an AUP.
- **Accountability**—Typically, an organization's human resources department is accountable for implementing proper employee background checks, which should be performed for individuals who will be accessing sensitive data.

Risks, Threats, and Vulnerabilities Commonly Found in the User Domain

The User Domain is the weakest link in an IT infrastructure. Anyone responsible for computer security must understand what motivates someone to compromise an organization's system, applications, or data. This domain is where the first layer of defense starts for a layered security strategy. **TABLE 1-2** lists the risks and threats commonly found in this domain as well as plans you can use to prevent them.

TABLE 1-2 Risks, threats, vulnerabilities, and mitigation plans for the User Domain.

RISK, THREAT, OR VULNERABILITY	MITIGATION
Unauthorized access	Users must be made aware of phishing emails, pretexting or cons, keyboard loggers, and perpetrators impersonating an IT or delivery person in an attempt to obtain logon ID and password credentials.
Lack of user awareness	Conduct security awareness training, display security awareness posters, insert reminders in banner greetings, and send email reminders to employees.
User apathy toward policies	Conduct annual security awareness training, implement AUP, update staff manual and handbook, discuss during performance reviews.
Security policy violations	Place employee on probation, review AUP and employee manual, discuss during performance reviews.
User insertion of CD/DVDs and USB drives with personal photos, music, and videos	Disable internal CD/DVD drives and USB ports. Enable automatic antivirus scans for inserted media drives, files, and email attachments. An antivirus scanning system examines all new files on a computer's hard drive for viruses. Set up antivirus scanning for emails with attachments.
User downloads of photos, music, and videos	Enable **content filtering** and antivirus scanning for email attachments. Content-filtering network devices are configured to permit or deny specific domain names in accordance with AUP definitions.
User destruction of systems, applications, or data	Restrict users' access to only those systems, applications, and data needed to perform their jobs. Minimize write/delete permissions to the data owner only.
Attacks on the organization or acts of sabotage by disgruntled employees	Track and monitor abnormal employee behavior, erratic job performance, and use of IT infrastructure during off-hours. Begin IT access control lockout procedures based on AUP monitoring and compliance.
Employee romance gone bad	Track and monitor abnormal employee behavior and use of IT infrastructure during off-hours. Begin IT access control lockout procedures based on AUP monitoring and compliance.
Employee blackmail or extortion	Track and monitor abnormal employee behavior and use of IT infrastructure during off-hours. Enable **intrusion detection system/intrusion prevention system (IDS/IPS)** monitoring for sensitive employee positions and access. IDS/IPS security appliances examine the IP data streams for inbound and outbound traffic. Alarms and alerts programmed within an IDS/IPS help identify abnormal traffic and can block IP traffic as per policy definition.

Workstation Domain

The Workstation Domain includes all the workstations where the production of an organization takes place. A **workstation** can be any device that connects to the network, such as desktop or laptop computers, smartphones, tablets, and other lightweight computers (e.g., Chromebooks and Raspberry Pi computers). More details about mobile devices can be found in the "Remote Access Domain" section of this chapter.

Moreover, a workstation computer can be either a thin or a thick client. A true **thin client** can refer to a software or an actual computer with no hard drive that runs on a network and relies on a server to provide applications, data, and all processing. More commonly, regular computers with normal hard drives are used as thin clients such that most of the "real" work occurs on a server or in the cloud. Thin clients are commonly used in large organizations, libraries, and schools. In contrast, a **thick client** has more fully featured hardware that contains a hard drive and applications and processes data locally, going to the server or cloud mainly for file storage.

Workstation Domain Roles, Responsibilities, and Accountability

Following is an overview of what should go on in the Workstation Domain:

- **Roles and tasks**—An organization's staff should have the access necessary to be productive. Tasks include configuring hardware, hardening systems, and verifying antivirus files. **Hardening** a system is the process of ensuring that controls are in place to handle any known threats, and it includes activities such as ensuring that all computers have the latest software revisions, security patches, and system configurations. The Workstation Domain also needs additional layers of defense, a tactic referred to as *defense in depth*. Another common defense layer is implementing workstation logon IDs and passwords to protect this domain's entry into the IT infrastructure.
- **Responsibilities**—An organization's desktop support group is responsible for the Workstation Domain, including enforcing defined standards, which is critical to ensuring the integrity of user workstations and data. Typically, the human resources department defines proper access controls for workers based on their jobs, and IT security

personnel then assign access rights to systems, applications, and data based on this definition. Moreover, the IT security personnel must safeguard controls within the Workstation Domain.

- **Accountability**—An organization's IT desktop manager is typically accountable for allowing employees the greatest use of the Workstation Domain, and the director of IT security is generally in charge of ensuring that the Workstation Domain conforms to policy.

Risks, Threats, and Vulnerabilities Commonly Found in the Workstation Domain

The Workstation Domain requires tight security and access controls, through logon IDs and passwords, because this domain is where users first access systems, applications, and data. The Workstation Domain is where the second layer of defense is required. **TABLE 1-3** lists the risks, threats, and vulnerabilities commonly found in the Workstation Domain along with ways to protect against them.

TABLE 1-3 Risks, threats, vulnerabilities, and mitigation plans for the Workstation Domain.

RISK, THREAT, OR VULNERABILITY	MITIGATION
Unauthorized access to workstation	Enable password protection on workstations for access. Enable auto screen lockout for inactive times. Disable system administration rights for users.
Unauthorized access to systems, applications, and data	Define strict access control policies, standards, procedures, and guidelines. Implement a second level or layer of authentication to applications that contain sensitive data (e.g., two-factor authentication).
Desktop or laptop computer operating system software vulnerabilities	Define a workstation operating system **vulnerability window** policy and standard. The vulnerability window is the time from when a workstation is exposed to a known vulnerability until it is patched. Perform frequent vulnerability assessment scans as part of ongoing security operations.
Desktop or laptop application software vulnerabilities and software patch updates	Define a workstation application **software vulnerability** window policy. Update application software and security patches according to defined policies, standards, procedures, and guidelines.
Infection of a user's workstation or laptop computer by viruses, malicious code, or malware	Use workstation antivirus and malicious code policies, standards, procedures, and guidelines. Enable an automated antivirus protection solution that scans and updates individual workstations with proper protection.

RISK, THREAT, OR VULNERABILITY	MITIGATION
User insertion of CDs/DVDs or USB thumb drives into the organization's computers	Deactivate all CD/DVD and USB ports. Enable automatic antivirus scans for inserted CDs/DVDs and USB thumb drives that have files.
User downloads of photos, music, or videos via the Internet	Use content filtering and antivirus scanning at Internet entry and exit. Enable workstation auto scans for all new files and automatic file quarantine for unknown file types.
User violation of AUP, which creates security risk for the organization's IT infrastructure	Mandate annual security awareness training for all employees. Set up security awareness campaigns and programs throughout the year.
Employees want to use their own smartphones or tablets, driving the need to support Bring Your Own Device (BYOD)	Develop a BYOD policy and procedure that allows employees to use their personal smartphones or other mobile devices. Typically, BYOD policies and procedures permit the organization to data wipe the employee's smartphone or mobile device if it is lost or the employee is terminated.

LAN Domain

The third component in the IT infrastructure is the LAN Domain. A **local area network (LAN)** is a collection of computers and devices connected to one another or to a common connection medium, which can include wires, fiber-optic cables, or radio waves. LANs are generally organized by function or department, and users get access to their department's LAN and other applications according to what their job requires. Once connected, computers can access systems, applications, and data and possibly the Internet.

The physical part of the LAN Domain consists of the following:

- **Network interface controller (NIC)**—The **network interface controller (NIC)** is the interface between the computer and the LAN physical media. The NIC has a 6-byte Media Access Control (MAC) layer address that serves as the NIC's unique hardware identifier.
- **Ethernet LAN**—This is a LAN solution based on the IEEE 802.3 CSMA/CD standard for 10/100/1,000 Mbps Ethernet networking. **Ethernet** is the most popular LAN standard and is based on the **Institute of Electrical and Electronics Engineers (IEEE)** 802.3 **Carrier Sense Multiple Access/Collision Detection (CSMA/CD)**

specification. Ethernet is available in 10-Mbps, 100-Mbps, 1-Gbps, 10-Gbps, 40-Gbps, and now 100-Gbps speeds for campus and metro Ethernet backbone connections.

- **Unshielded twisted-pair (UTP) cabling**—This workstation cabling uses RJ-45 connectors and jacks to physically connect to a 100-Mbps/1-Gbps/10-Gbps Ethernet LAN switch. Today, organizations use Category 5 or 6 UTP transmission media to support high-speed data communications.
- **LAN switch**—A device that connects workstations into a physical Ethernet LAN. A switch provides dedicated Ethernet LAN connectivity for workstations and servers to deliver maximum throughput and performance for each workstation. There are two kinds of LAN switches. A **Layer 2 switch** examines the MAC layer address and makes forwarding decisions based on MAC layer address tables. A **Layer 3 switch** examines the network layer address and routes packets based on routing protocol path determination decisions. A Layer 3 switch is the same thing as a router.
- **File server and print server**—High-powered computers that provide file sharing and data storage for users within a department. Print servers support shared printer use within a department.
- **Wireless access point (WAP)**—For **wireless LANs (WLANs)**, radio transceivers are used to transmit IP packets from a WLAN NIC to a **wireless access point (WAP)**. The WAP transmits WLAN signals so that mobile laptops can connect. The WAP connects back to the LAN switch using UTP cabling.

The logical part of the LAN Domain consists of the following:

- **System administration**—Setup of user LAN accounts with logon ID and password access controls (i.e., user logon information).
- **Design of directory and file services**—The servers, directories, and folders to which the user can gain access.
- **Configuration of workstation and server TCP/IP software and communication protocols**—This configuration involves, for example, IP addressing, the **IP default gateway router**, and subnet mask

address. The IP default gateway router acts as the entry and exit to the LAN. The subnet mask address defines the IP network number and IP host number.

- **Design of server disk storage space; backup and recovery of user data**—Provision for user data files on LAN disk storage areas where data is backed up and archived daily. In the event of data loss or corruption, data files can be recovered from the backed-up files.
- **Design of virtual LANs (VLANs)**—With Layer 2 and Layer 3 LAN switches, Ethernet ports can be configured to be on the same **virtual LAN (VLAN)**, even though they may be connected to different physically connected LANs, which is the same thing as configuring workstations and servers to be on the same Ethernet LAN or broadcast domain.

LAN Domain Roles, Responsibilities, and Accountability

Following is an overview of what should go on in the LAN Domain:

- **Roles and tasks**—The LAN Domain includes both physical network components and logical configuration of services for users. Management of the physical components includes:
  - Cabling
  - NICs
  - LAN switches
  - WAPs

  LAN system administration includes maintaining the master lists of user accounts and access rights. In this domain, two-factor authentication might be required. Two-factor authentication is like a gate whereby users must confirm their identity a second time, which mitigates the risk of unauthorized physical access.
- **Responsibilities**—The LAN support group is in charge of the LAN Domain, which includes both the physical components and logical elements. LAN system administrators must maintain and support departments' file and print services and configure access controls for users.

- **Accountability**—The LAN manager's duty is to maximize use and integrity of data within the LAN Domain. Typically, the director of IT security must ensure that the LAN Domain conforms to policy.

Risks, Threats, and Vulnerabilities Commonly Found in the LAN Domain

The LAN Domain needs strong security and access controls. Users can access company-wide systems, applications, and data from this domain, which is where the third layer of defense is required to protect the IT infrastructure as well as the domain itself. **TABLE 1-4** lists the risks, threats, and vulnerabilities commonly found in the LAN Domain along with appropriate risk-reducing strategies.

TABLE 1-4 Risks, threats, vulnerabilities, and mitigation plans for the LAN Domain.

RISK, THREAT, OR VULNERABILITY	MITIGATION
Unauthorized access to LAN	Make sure wiring closets, data centers, and computer rooms are secure. Do not allow anyone access without proper ID.
Unauthorized access to systems, applications, and data	Define strict access control policies, standards, procedures, and guidelines. Implement a second-level identity check to gain access to sensitive systems, applications, and data. Restrict users from access to LAN folders and read, write, and delete privileges on specific documents as needed.
LAN server operating system software vulnerabilities	Define server, desktop, and laptop vulnerability window policies, standards, procedures, and guidelines. Conduct periodic LAN Domain vulnerability assessments to find software gaps. A vulnerability assessment is a software review that identifies bugs or errors in software. These bugs and errors go away when software patches and fixes are uploaded.
LAN server application software vulnerabilities and software patch updates	Define a strict software vulnerability window policy requiring quick software patching.
Unauthorized access by rogue users on WLANs	Use WLAN **network keys** that require a password for wireless access. Turn off broadcasting on WAPs. Require second-level authentication before granting WLAN access.

RISK, THREAT, OR VULNERABILITY	MITIGATION
Compromised confidentiality of data transmissions via WLAN	Implement encryption between workstation and WAP to maintain confidentiality.
LAN servers with different hardware, operating systems, and software make them difficult to manage and troubleshoot	Implement LAN server and configuration standards, procedures, and guidelines.

LAN-to-WAN Domain

The LAN-to-WAN Domain is where the IT infrastructure links to a WAN and the Internet. Unfortunately, connecting to the Internet is like rolling out the red carpet for bad actors. The Internet is open, public, and easily accessible by anyone, and most Internet traffic is cleartext, which means it's visible and not private. Network applications use two common transport protocols: Transmission Control Protocol (TCP) and User Datagram Protocol (UDP). Both TCP and UDP use port numbers to identify the application or function; these port numbers function like channels on a TV, dictating which station you're watching. When a packet is sent via TCP or UDP, its port number appears in the packet header. Because many services are associated with a common port number, knowing the port number essentially reveals what type of packet it is, which is like advertising to the world what is being transmitted.

Examples of common TCP and UDP port numbers include the following:

- **Port 80: Hypertext Transfer Protocol (HTTP)** —HTTP is the communications protocol between web browsers and websites with data in cleartext.
- **Port 20: File Transfer Protocol (FTP)** —FTP is a protocol for performing file transfers. FTP uses TCP as a connection-oriented data transmission but in cleartext, including the password. *Connection-*

oriented means individual packets are numbered and acknowledged as being received, to increase integrity of the file transfer.

- **Port 69: Trivial File Transfer Protocol (TFTP)** —TFTP is a protocol for performing file transfers. TFTP utilizes UDP as a connectionless data transmission but in cleartext. This protocol is used for small and quick file transfers given that it does not guarantee individual packet delivery.
- **Port 23: Terminal Network (Telnet)**—**Telnet** is a network protocol for performing remote terminal access to another device, and it uses TCP and sends data in cleartext.
- **Port 22: Secure Shell (SSH)**—SSH is a network protocol for performing remote terminal access to another device. SSH encrypts the data transmission for maintaining confidentiality of communications.

A complete list of well-known port numbers from 0 to 1023 is maintained by the Internet Assigned Numbers Authority (IANA). The IANA helps coordinate global domain name services, IP addressing, and other resources. Well-known port numbers are on the IANA website at *www.iana.org/assignments/service-names-port-numbers/service-names-port-numbers.xhtml*.

Because the TCP/IP suite of protocols lacks security, the need is greater for security controls in dealing with protocols in this family.

LAN-to-WAN Domain Roles, Responsibilities, and Accountability

Following is an overview of what should go on in the LAN-to-WAN Domain:

- **Roles and tasks**—The LAN-to-WAN Domain includes both the physical pieces and logical design of security appliances and is one of the most complex areas to secure within an IT infrastructure. Security must be maintained while also giving users as much access as possible, physical parts need to be managed to give easy access to the service, and the security appliances must be logically configured to adhere to policy definitions.

  Ensuring that these items are adhered to will get the most out of availability, ensure data integrity, and maintain confidentiality. The

roles and tasks required within the LAN-to-WAN Domain include managing and configuring the following:

- **IP routers**—A network device used to transport IP packets to and from the Internet or WAN. IP packets are forwarded based on path determination decisions. Configuration tasks include IP routing and access control lists (ACLs), which, like a filter, are used to permit and deny traffic.
- **IP stateful firewalls**—An **IP stateful firewall** is a security appliance used to filter inbound IP packets based on various ACL definitions configured for IP, TCP, and UDP packet headers.
- **Demilitarized zone (DMZ)**—The DMZ is a LAN segment in the LAN-to-WAN Domain that acts as a buffer zone for inbound and outbound IP traffic. External servers, such as web, proxy, and email servers, can be placed here for greater isolation and screening of IP traffic.
- **Intrusion detection system (IDS)**—An IDS security appliance examines IP data streams for common attack and malicious intent patterns. IDSs are passive, going only so far as to trigger an alarm; they will not actively block traffic.
- **Intrusion prevention system (IPS)**—An IPS does the same thing as an IDS but can block IP data streams identified as malicious. IPSs can end the actual communication session, filter by source IP addresses, and block access to the targeted host.
- **Proxy server**—A proxy server acts as a middleman between a workstation and the external target. Traffic goes to the intermediary server that is acting as the proxy. Data can be analyzed and properly screened before it is relayed into the IT infrastructure by what are called proxy firewalls or application gateway firewalls.
- **Web content filter**—This security appliance can prevent content from entering an IT infrastructure based on filtering of domain names or keywords within domain names.
- **Email content filter and quarantine system**—This security appliance can block content within emails or unknown file attachments for proper antivirus screening and quarantining. Upon review, the email and attachments can be forwarded to the user.

    - **Security information and event management (SIEM)**—SIEM includes monitoring the IT assets within the LAN-to-WAN Domain, including the DMZ VLAN, firewalls, IDS/IPS, and other security appliances, to maximize confidentiality, integrity, and availability and monitor for security incidents and alarms triggered by specific events.
- **Responsibilities**—The network security group is responsible for the LAN-to-WAN Domain and includes both the physical components and logical elements. Group members are responsible for applying the defined security controls.
- **Accountability**—An organization's WAN network manager has a duty to manage the LAN-to-WAN Domain. Typically, the director of IT security ensures that this domain's security policies, standards, procedures, and guidelines are used.

Risks, Threats, and Vulnerabilities Commonly Found in the LAN-to-WAN Domain

The LAN-to-WAN Domain requires strict security controls given the risks and threats of connecting to the Internet. This domain is where all data travels into and out of the IT infrastructure. The LAN-to-WAN Domain provides Internet access for the entire organization and acts as the entry and exit point for the WAN, which is also known as the Internet ingress and egress point. The LAN-to-WAN Domain is where the fourth layer of defense is required. **TABLE 1-5** lists the risks, threats, and vulnerabilities commonly found in the LAN-to-WAN Domain along with appropriate risk-reduction strategies.

TABLE 1-5 Risks, threats, vulnerabilities, and mitigation plans for the LAN-to-WAN Domain.

RISK, THREAT, OR VULNERABILITY	MITIGATION
Unauthorized network probing and port scanning	Disable ping, probing, and port scanning on all exterior IP devices within the LAN-to-WAN Domain. Ping uses the Internet Control Message Protocol (ICMP) echo-request and echo-reply protocol. Disallow IP port numbers used for probing and scanning and monitor with IDS/IPS.

RISK, THREAT, OR VULNERABILITY	MITIGATION
Unauthorized access through the LAN-to-WAN Domain	Apply strict security monitoring controls for intrusion detection and prevention. Monitor for inbound IP traffic anomalies and malicious-intent traffic. Block traffic immediately if malicious.
Denial of service (DoS)/distributed denial of service (DDoS) attacks on external public-facing IPs and Internet links	Upstream Internet service providers (ISPs) must participate in DoS/DDoS attack prevention and discarding of IP packets when a stream of half-open TCP synchronize (SYN) packets start to flood the ISP link.
IP router, firewall, and network appliance operating system software vulnerability	Define a strict zero-day vulnerability window definition. Update devices with security fixes and software patches right away.
IP router, firewall, and network appliance configuration file errors or weaknesses	Conduct postconfiguration penetration tests of the layered security solution within the LAN-to-WAN Domain. Test inbound and outbound traffic and fix any gaps.
The ability for remote users to access the organization's infrastructure and download sensitive data	Apply and enforce the organization's data classification standard. Deny outbound traffic, using source IP addresses in ACLs. If remote downloading is allowed, encrypt where necessary.
Download of unknown file type attachments from unknown sources	Apply file transfer monitoring, scanning, and alarming for unknown file types from unknown sources.
Unknown email attachments and embedded Uniform Resource Locator (URL) links received by local users	Apply email server and attachment antivirus and email quarantining for unknown file types. Stop domain-name website access, based on content-filtering policies.
Lost productivity due to local users surfing the web and not focusing on work tasks	Apply domain-name content filtering at the Internet entry and access point.

WAN Domain

The Wide Area Network (WAN) Domain connects remote locations. As network costs drop, organizations can afford faster Internet and WAN connections. Today, telecommunications service providers sell the following:

- **Nationwide optical backbones**—Optical backbone trunks for private optical backbone networks.

- **End-to-end IP transport**—IP services and connectivity, using the service provider's IP networking infrastructure.
- **Multisite WAN cloud services**—IP services and connectivity offered for multisite services, such as Multiprotocol Label Switching (MPLS) WAN services. MPLS uses labels or tags to make virtual connections between endpoints in a WAN.
- **Metropolitan Ethernet LAN connectivity**—Ethernet LAN connectivity offered within a city's area network.
- **Dedicated Internet access**—A broadband Internet communication link usually shared within an organization.
- **Managed services**—Router management and security appliance management 24/7/365.
- **Service-level agreements (SLAs)**—Contractual commitments for monthly service offerings, such as availability, packet loss, and response time to fix problems.

WAN services can include dedicated Internet access and managed services for customers' routers and firewalls. Management agreements for availability and response times to outages are common. Networks, routers, and equipment require continuous monitoring and management to keep WAN service available.

WAN Domain Roles, Responsibilities, and Accountability

Following is an overview of what should go on in the WAN Domain:

- **Roles and tasks**—The WAN Domain includes both physical components and the logical design of routers and communication equipment and is the second most complex area to secure within an IT infrastructure. The goal is to allow users the most access possible while making sure that what goes in and out is safe. The roles and tasks required within the WAN Domain include managing and configuring the following:
    - **WAN communication links**—These links are the physical communication links provided as a digital or optical service

terminated at a company's facility. Broadband connection speeds can range among the following:

- DS0 (64 Kbps) to DS1 (1.544 Mbps) to DS3 (45 Mbps) for digital service
- OC-3 (155 Mbps) to OC-12 (622 Mbps) to OC-48 (2,488 Mbps) for optical service
- 10/100/1,000 Mbps metro Ethernet LAN connectivity, depending on physical distance

- **IP network design**—This is the logical design of the IP network and addressing schema and requires network engineering, design of alternate paths, and selection of IP routing protocol.
- **IP stateful firewall**—This is a security appliance that is used to filter IP packets and block unwanted IP, TCP, and UDP packet types from entering or leaving the network. Firewalls can be installed on workstations or routers or as stand-alone devices protecting LAN segments.
- **IP router configuration**—This is the actual router configuration information for the WAN backbone and edge routers used for IP connections to remote locations. The configuration must be based on the IP network design and addressing schema.
- **Virtual private networks (VPNs)**—A **virtual private network (VPN)** is a dedicated encrypted tunnel from one endpoint to another. The VPN tunnel can be created between a remote workstation, using the public Internet and a VPN router or a secure browser and a **Secure Sockets Layer virtual private network (SSL-VPN)** website.
- **Multiprotocol Label Switching (MPLS)**—MPLS is a WAN software feature that allows customers to maximize performance. MPLS labels IP packets for rapid transport through virtual tunnels between designated endpoints. It is a form of the Layer 1/Layer 3 overlay network and bypasses the routing function's path determination process once a long-lived flow has been configured or dynamically determined.
- **Simple Network Management Protocol (SNMP) network monitoring and management**—SNMP is used for network device

monitoring, alarm, and performance.

  - **Router and equipment maintenance**—A requirement to perform hardware and firmware updates, upload new operating system software, and configure routers and filters.

- **Responsibilities**—The network engineer or WAN group is responsible for the WAN Domain. These responsibilities include both the physical components and logical elements. Network engineers and security practitioners set up security controls according to defined policies. Note that, because of the complexities of IP network engineering, many groups now outsource management of their WAN and routers to service providers. This service includes SLAs that ensure that the system is available and that problems are solved quickly. In the event of a WAN connection outage, customers call a toll-free number for their service provider's network operations center (NOC).
- **Accountability**—An organization's IT network manager must maintain, update, and provide technical support for the WAN Domain. Typically, the director of IT security ensures that the company meets WAN Domain security policies, standards, procedures, and guidelines.

Some organizations use the public Internet as their WAN infrastructure. Although it is cheaper, the Internet does not guarantee delivery or security.

Risks, Threats, and Vulnerabilities Commonly Found in the WAN Domain (Internet)

Telecommunication service providers are in the business of providing WAN connectivity for end-to-end communications and are responsible for securing their network infrastructure. Customers who sign up for WAN communication services must review the terms, conditions, and limitations of liability within their service contract to determine where the service provider's duties start and end regarding router and security management. The most critical aspect of a WAN services contract is how the service provider supplies troubleshooting, network management, and security management services.

The WAN Domain represents the fifth layer of security for an overall IT infrastructure. **TABLE 1-6** lists the risks, threats, and vulnerabilities found in the Internet segment of the WAN Domain and appropriate risk-reducing strategies.

TABLE 1-6 Risks, threats, vulnerabilities, and mitigation plans for the WAN Domain (Internet).

RISK, THREAT, OR VULNERABILITY	MITIGATION
Open, public, easily accessible to anyone who wants to connect	Apply AUPs in accord with the document "RFC 1087: Ethics and the Internet." Enact new laws regarding unauthorized access to systems, malicious attacks on IT infrastructures, and financial loss due to malicious outages.
Most Internet traffic sent in cleartext	Prohibit using the Internet for private communications without encryption and VPN tunnels. If you have a data classification standard, specifically follow its policies, procedures, and guidelines.
Vulnerable to eavesdropping	Use encryption and VPN tunnels for end-to-end secure IP communications. If you have a data classification standard, specifically follow its policies, procedures, and guidelines.
Vulnerable to malicious attacks	Deploy layered LAN-to-WAN security countermeasures, DMZ with IP stateful firewalls, IDS/IPS for security monitoring, and quarantining of unknown email file attachments.
Vulnerable to DoS, DDoS, TCP SYN flooding, and IP spoofing attacks	Apply filters on exterior IP stateful firewalls and IP router WAN interfaces to block TCP SYN "open connections" and ICMP (echo-request) ping packets. Alert the ISP to put the proper filters on its IP router WAN interfaces in accordance with CERT Advisory CA-1996-21, which can be found here: *https://resources.sei.cmu.edu/library/asset-view.cfm?assetid=496170* .
Vulnerable to corruption of information and data	Encrypt IP data transmissions with VPNs. Back up and store data in offsite data vaults (online or physical data backup) with tested recovery procedures.
Inherently insecure TCP/IP applications (e.g., HTTP, FTP, and TFTP)	Refer to the data classification standard for proper handling of data and use of TCP/IP applications. Never use TCP/IP applications for confidential data without proper encryption. Create a network management VLAN and isolate TFTP and SNMP traffic used for network management.

RISK, THREAT, OR VULNERABILITY	MITIGATION
Hackers, attackers, and perpetrators email Trojans, worms, and malicious software	Scan all email attachments for type, antivirus, and malicious software at the LAN-to-WAN Domain. Isolate and quarantine unknown file attachments until further security review has been conducted. Provide security awareness training to remind employees of dangers, such as embedded URL links and email attachments from unknown parties, and to urge them to be careful when clicking on links and opening files.

Besides selling WAN connectivity services, some telecommunications service providers now also provide security management services. The following section presents WAN connectivity risks, threats, and vulnerabilities and risk-reducing strategies.

Risks, Threats, and Vulnerabilities Commonly Found in the WAN Domain (Connectivity)

Telecommunications companies are responsible for building and transporting customer IP traffic, which sometimes is bundled with dedicated Internet access to provide shared broadband access organization-wide. If organizations outsource their WAN infrastructure, management and security must extend to the service provider. Therefore, organizations must define their security policies and needs for the managed security provider to implement. **TABLE 1-7** lists the risks, threats, and vulnerabilities related to connectivity found in the WAN Domain and appropriate risk-reducing strategies.

TABLE 1-7 Risks, threats, vulnerabilities, and mitigation plans for the WAN Domain (connectivity).

RISK, THREAT, OR VULNERABILITY	MITIGATION

RISK, THREAT, OR VULNERABILITY	MITIGATION
Commingling of WAN IP traffic on the same service provider router and infrastructure	Encrypt confidential data transmissions through service provider's WAN using VPN tunnels.
Maintaining high WAN service availability	Obtain WAN service availability SLAs. Deploy redundant Internet and WAN connections when 100 percent availability is required.
Maximizing WAN performance and throughput	Apply WAN optimization and data compression solutions when accessing remote systems, applications, and data. Enable ACLs on outbound router WAN interfaces in keeping with policy.
Using SNMP network management applications and protocols maliciously (e.g., ICMP, Telnet, SNMP, and DNS)	Create separate WAN network management VLANs. Use strict firewall ACLs that allow SNMP manager and router IP addresses through the LAN-to-WAN Domain.
SNMP alarms and security monitoring 24/7/365	Outsource security operations and monitoring. Expand services to include managed security.

Remote Access Domain

The Remote Access Domain connects remote users to the organization's IT infrastructure. Being able to remotely connect is critical for staff members who work in the field or from home, for example, outside sales reps, technical support specialists, or health care professionals. Remote access has become almost a normal mode of communication because coffee shops and many other businesses offer free **Wi-Fi**. Conducting business and staying connected while physically separated or socially distanced has become easier than ever. Global access makes it easy to connect to the Internet, email, social media, and other business applications anywhere you can find a Wi-Fi hotspot. The Remote Access Domain is important to have but dangerous to use because it introduces many risks and threats from the Internet.

Today's mobile worker depends on the following:

- **Highly available cell phone service**—Mobile workers need cell phone service to get in touch with office and support teams. Even though Wi-Fi may provide better bandwidth, users must stay within range of an access point, which makes cell service the only means for users to be truly mobile.

- **Real-time access for critical communications**—Use of text messaging or instant messaging (IM) chat on smartphones or other devices provides quick answers to short questions and does not require users to completely interrupt what they are doing.
- **Access to email from a mobile device**—Integration of email with smartphones and tablets provides users the ability to quickly respond to important email messages.
- **Broadband Wi-Fi Internet access**—Many national service providers offer Wi-Fi broadband access cards, which allow wireless access in a growing number of locations.
- **Local Wi-Fi hotspot**—Wi-Fi hotspots are abundant, including in airports, libraries, coffee shops, and retailers. Most are free, but some require that users pay for access.
- **Broadband Internet access to home office**—Staffers who work from home require broadband Internet access. This service is usually bundled with VoIP telephone and digital TV services.
- **Secure remote access to a company's IT infrastructure**—Remote workers require secure VPN tunnels to encrypt all IP data transmissions through the public Internet. VPN encryption is critical if private data is being accessed remotely.

The scope of this domain is limited to remote access via the Internet and IP communications. The logical configuration of the Remote Access Domain requires IP network engineering and VPN solutions. This section addresses individual and large-scale remote access for many remote users.

Remote Access Domain Roles, Responsibilities, and Accountability

Following is an overview of what should go on in the Remote Access Domain:

- **Roles and tasks**—The Remote Access Domain connects mobile users to their IT systems through the public Internet. The mobile user must have a remote IP device able to connect to the Internet. Besides laptop computers, mobile users can use smartphones and tablets as handheld computers. The mobile software on these devices makes possible

remote phone calls, voicemail, email, text messaging, and web browsing.

The roles and tasks required within the Remote Access Domain include managing and designing the following:

- **Smartphones and tablets**—Company-issued devices should be loaded with up-to-date firmware, operating system software, and patches according to defined policies. Policy should require use of passwords on this equipment.
- **Laptop VPN client software**—When organizations use VPN tunnels between the LAN-to-WAN Domain and remote-user laptop computers, VPN software that meets the organization's specific needs and works with its other software must be selected.
- **Secure browser software**—Webpages that use HTTPS need secure browsers. HTTPS encrypts the data transfer between secure browsers and secure webpages.
- **VPN routers, VPN firewalls, or VPN concentrators**—Remote access VPN tunnels end at the VPN router, VPN firewall, or VPN concentrator, usually within the LAN-to-WAN Domain. All data is encrypted between the VPN client (remote laptop) and the VPN router, firewall, or concentrator, hence the name *tunnel*.
- **Secure Sockets Layer (SSL)/VPN web server**—SSL uses 128-bit encryption between a safe HTTPS webpage and a safe browser. This encrypted VPN tunnel gives end-to-end privacy for remote webpage data sharing.
- **Authentication server**—A server that performs a second-level authentication to verify users seeking remote access.

- **Responsibilities**—The network engineer or WAN group is usually in charge of the Remote Access Domain. These responsibilities include both the hardware components and logical elements. Network engineers and security practitioners are in charge of applying security controls according to policies. These policies cover maintaining, updating, and troubleshooting the hardware and logical remote access connection for the Remote Access Domain. These functions require managing the following:
  - IP routers

    - IP stateful firewalls
    - VPN tunnels
    - Security monitoring devices
    - Authentication servers
- **Accountability**—An organization's WAN network manager is accountable for the Remote Access Domain. Typically, the director of IT security must ensure that the Remote Access Domain security plans, standards, methods, and guidelines are used.

Risks from Backdoor Analog Phone Lines and Modems

Some maintenance vendors use analog phone lines and modems to reach equipment, which means they do not use IPs or SNMPs. Although using these analog means to reach equipment is convenient, they allow an insecure backdoor into the IT system because attackers use tools that can get around an analog modem's password. Be alert for user workstations that are equipped with an analog modem connected to a backdoor analog phone line. A company might not know that its IT staff and software developers have set up these backdoors, which can present a risk because analog modems generally have few security controls.

Following are some of the best ways to reduce these risks and threats:

- Do not install single analog phone lines without going through a private branch exchange (PBX) or VoIP phone system.
- Work with local phone service companies to make sure no single analog phone lines are installed.
- Block unidentified calls (i.e., calls that appear on caller ID screens as "unknown") from entering the phone system.
- Watch call-detail record (CDR) reports from PBX and VoIP phone systems for rogue phone numbers and abnormal call patterns.

Risks, Threats, and Vulnerabilities Commonly Found in the Remote Access Domain

Remote access is dangerous yet necessary for organizations that rely on a mobile workforce, such as sales reps, consultants, and support staff. As organizations cut costs, many urge staff to work from home, for which the WAN is the public Internet. Making those connections secure is a top job. You will use the organization's strict data classification standard to verify users and encrypt data.

Remote access security controls must use the following:

- **Identification**—The process of providing identifying information, such as a username, a logon ID, or an account number.
- **Authentication**—This is the process for proving that remote users are who they claim to be. The most common authentication method is supplying a password. Many organizations use second-level verifying services, such as a token (hardware or software), biometric fingerprint reader, or smart card. A token can be a hardware device that sends a random number or a software token that text messages a number to the user. A biometric fingerprint reader grants access only when the user's fingerprint is matched with one stored in the system. A smart card is like a credit card that acts like a token. It has a microprocessor chip that verifies the user with a smart-card reader.
- **Authorization**—The process of granting rights to use an organization's IT assets, systems, applications, and data to a specific user.
- **Accountability**—The process of recording users' actions. The recorded information is often used to link users to system events.

The Remote Access Domain represents the sixth layer of defense for a typical IT infrastructure. **TABLE 1-8** lists Remote Access Domain risks, threats, and vulnerabilities as well as risk-mitigation strategies.

TABLE 1-8 Risks, threats, vulnerabilities, and mitigation plans for the Remote Access Domain.

RISK, THREAT, OR VULNERABILITY	MITIGATION
Brute-force user ID and password attacks	Establish user ID and password policies requiring periodic changes (i.e., every 30 or 60 days). Passwords must be used, and they must have more than eight characters and include numbers and letters.
Multiple logon retries and access control attacks	Set automatic blocking for attempted logon retries (e.g., block user access after three logon attempts have failed).
Unauthorized remote access to IT systems, applications, and data	Apply first-level (i.e., user ID and password) and second-level (i.e., tokens, biometrics, and smart cards) security for remote access to sensitive systems, applications, and data.
Private or confidential data compromised remotely	Encrypt all private data within the database or hard drive. If data is stolen, the thief cannot use or sell it because it will be encrypted.
Data leakage in violation of existing data classification standards	Apply security countermeasures in the LAN-to-WAN Domain, including data leakage security–monitoring tools and tracking, as per the organization's data classification standard.
A mobile worker's laptop is stolen	Encrypt the data on the hard drive if the user has access to private or confidential data. Apply real-time lockout rules when told of a lost or stolen laptop.
Mobile worker token or other authentication stolen	Apply real-time lockout procedures if a token has been lost or a device compromised.

System/Application Domain

The System/Application Domain holds all the mission-critical systems, applications, and data. Authorized users may have access to many components in this domain, and secure access may require second-level checks.

Examples of applications that may require second-level authentication include the following:

- **Human resources and payroll**—Only staff who work on payroll services need access to this private data and confidential information.
- **Accounting and financial**—Executive managers need access to accounting and financial data to make sound business decisions. Securing financial data requires unique security controls with access limited to those who need it. Moreover, publicly traded companies are

subject to the Sarbanes-Oxley (SOX) compliance law, which requires security.

- **Customer relationship management (CRM)**—Customer service reps need real-time access to information that includes customer purchasing history and private data.
- **Sales order entry**—Sales professionals need access to the sales order entry and order tracking system. Private customer data must be kept safe.
- **U.S. military intelligence and tactics**—U.S. military commanders who make decisions on the battlefield use highly sensitive information. Access to that information must meet U.S. Department of Defense (DoD) data classification standards.

Technical TIP

Security controls keep private data and intellectual property safe. Encrypting data can stop bogus users because hackers looking for data know where people hide it and how to find it. Encrypting the data within databases and storage devices gives an added layer of security.

System/Application Domain Roles, Responsibilities, and Accountability

Following is an overview of what should go on in the System/Application Domain:

- **Roles and tasks**—The System/Application Domain consists of hardware, operating system software, applications, and data and includes hardware and its logical design. Because an organization's mission-critical applications and intellectual property assets are here, this domain must be secured both physically and logically.

  We limited the scope of the System/Application Domain to reducing risks, which include the following:

  - **Physical access to computer rooms, data centers, and wiring closets**—Set up a procedure to allow staff to enter secured area.

- **Server architecture**—Apply a converged server design that employs server blades and racks to combine their use and reduce costs.
- **Server operating systems and core environments**—Reduce the time that operating system software is open to attack by installing software updates and patches.
- **Virtualization servers**—Keep physical and logical virtual environments separate and extend layered security solutions into the cloud. Virtualization allows you to load many operating systems and applications, using one physical server.
- **System administration of application servers**—These servers provide ongoing server and system administration for users.
- **Data classification standard**—Review data classification standards, procedures, and guidelines on proper handling of data. Maintain safety of private data while in transport and in storage.
- **Software development life cycle (SDLC)**—Apply secure SDLC tactics when designing and developing software.
- **Testing and quality assurance**—Apply sound software testing, penetration testing, and quality assurance to fill security gaps and software weaknesses.
- **Storage, backup, and recovery procedures**—Follow data storage, backup, and recovery plans as set by the data classification standard.
- **Data archiving and retention**—Align policies, standards, procedures, and guidelines to digital storage and retention needs.
- **Business continuity plan (BCP)**—Conduct a business impact analysis (BIA) and decide which computer uses are most important. Define RTOs for each system. Prepare a BCP focused on those things that are most important for the business to keep going.
- **Disaster recovery plan (DRP)**—Prepare a DRP based on the BCP. Start DRP elements for the most important computer systems first. Organize a DRP team and a remote data center.

- **Responsibilities**—The responsibility for the System/Application Domain lies with the director of systems and applications and the director of software development. This domain includes the following:
  - Server systems administration
  - Database design and management
  - Designing access rights to systems and applications
  - Software development
  - Software development project management
  - Software coding
  - Software testing
  - Quality assurance
  - Production support
- **Accountability**—The directors of systems and applications and software development are accountable for the organization's production systems and uses. Typically, the director of IT security is accountable for ensuring that the System/Application Domain security policies, standards, procedures, and guidelines are in compliance.

Risks, Threats, and Vulnerabilities Commonly Found in the System/Application Domain

The System/Application Domain is where the organization's treasure lies—its data—whether private customer data, intellectual property, or national security information. This data is what attackers seek deep within an IT system, so protecting this treasure must be the goal of every organization. Loss of data is the greatest threat in the System/Application Domain.

With a data classification standard, types of data can be isolated in like groups. The more important the data, the deeper you should hide and store it. Consider encrypting data that is to be stored for a long time. The System/Application Domain represents the seventh layer of defense. **TABLE 1-9** lists common System/Application Domain risks, threats, and vulnerabilities as well as risk-mitigation strategies.

TABLE 1-9 Risks, threats, vulnerabilities, and mitigation plans for the System/Application Domain.

RISK, THREAT, OR VULNERABILITY	MITIGATION
Unauthorized access to data centers, computer rooms, and wiring closets	Apply policies, standards, procedures, and guidelines for staff and visitors to secure facilities.
Downtime of servers to perform maintenance	Create a system that brings together servers, storage, and networking.
Server operating systems software vulnerability	Define vulnerability windows for server operating system environments. Maintain hardened production server operating systems.
Insecure cloud computing virtual environments by default	Implement virtual firewalls and server segmentation on separate VLANs. A virtual firewall is a software-based firewall used in virtual environments.
Susceptibility of client-server and web applications	Conduct rigorous software and web application and penetration testing before launch.
Unauthorized access to systems	Follow data classification standards regarding stringent use of second-level authentication.
Data breach where private data of individuals is compromised	Separate private data elements into different databases. For archiving purposes, encrypt sensitive data at rest within databases and storage devices.
Loss or corruption of data	Implement daily data backups and offsite data storage for monthly data archiving. Define data recovery procedures based on defined RTOs.
Loss of backed-up data because backup media are reused	Convert all data into digital data for long-term storage. Retain backups from offsite data vaults based on defined RTOs.
Recovery of critical business functions potentially too time consuming to be useful	Develop a BCP for mission-critical applications to provide tactical steps for maintaining availability of operations.
Downtime of IT systems for an extended period after a disaster	Develop a disaster recovery plan specific to the recovery of mission-critical applications and data to maintain operations.

Weakest Link in the Security of an IT Infrastructure

The human is the weakest link in security. Even information systems security practitioners can make mistakes. Human error is a major risk and threat to any organization. Because no group can completely control any individual's behavior, every organization must be prepared for malicious users, untrained users, and careless users.

The following strategies can help reduce risk:

- Check the background of each job candidate carefully.
- Evaluate each staff member regularly.
- Rotate access to sensitive systems, applications, and data among different staff positions.
- Apply sound application and software testing and review for quality.
- Regularly review security plans throughout the seven domains of a typical IT system.
- Perform annual security control audits.

To build a respected and effective profession, information systems security professionals must operate ethically and comply with a code of conduct. This section explains why this tenet is the basis of the profession.

Ethics and the Internet

Imagine if there were no air traffic controllers to route and provide separation between aircraft. Trying to take off and land would be extremely dangerous, and many accidents would probably occur. Such a situation would wreak havoc.

Incredibly, cyberspace has no authorities that function like air traffic controllers. To make matters worse, human behavior online is often less mature than in normal social settings, and cyberspace has become the new

playground for today's bad actors. For these reasons, the demand for systems security professionals is growing rapidly.

The U.S. government and the Internet Architecture Board (IAB) has defined a policy regarding acceptable use of the Internet geared toward U.S. citizens. It is not a law nor a mandate, however; because cyberspace is global and entirely without borders, this policy cannot be enforced. Its use is based on common sense and personal integrity. The following sidebar presents the IAB's standard of ethics and the Internet.

Ethics are a matter of personal integrity. The responsibility of the systems security profession is doing what is right and stopping what is wrong. Use of the Internet is a privilege shared by all. It is a communications medium with no borders, no cultural bias, and no prejudice. Users are privileged to connect to the Internet, a privilege for which we should all be thankful. Unfortunately, bad guys use cyberspace to commit crimes and cause trouble. This bad element has created a global need for systems security professionals.

IT Security Policy Framework

Because cyberspace cannot continue to flourish without some assurances of user security, several laws now require organizations to keep personal data private. Businesses cannot operate effectively on an Internet where anyone can steal their data, making IT security crucial to any organization's ability to survive. This section introduces an **IT security policy framework**, which consists of policies, standards, procedures, and guidelines that reduce risks and threats.

Request for Comments (RFC) 1087: Ethics and the Internet

IAB Statement of Policy

The Internet is a national facility, of which the utility is largely a consequence of its wide availability and accessibility. Irresponsible use of this critical resource poses an enormous threat to its continued availability to the technical community. The U.S. government sponsors of this system have a fiduciary responsibility to the public to allocate government resources wisely and effectively. Justification for the support of this system suffers when highly disruptive abuses occur. Access to and use of the Internet are privileges and should be treated as such by all users of this system.

The IAB strongly endorses the view of the Division Advisory Panel of the National Science Foundation Division of Network, Communications Research and Infrastructure, which, in paraphrase, characterized as unethical and unacceptable any activity that purposely:

1. seeks to gain unauthorized access to the resources of the Internet,
2. disrupts the intended use of the Internet,
3. wastes resources (people, capacity, computer) through such actions,
4. destroys the integrity of computer-based information, and/or
5. compromises the privacy of users.

Definitions

An IT security policy framework contains four main components:

- **Policy**—A policy is a short written statement that the people in charge of an organization have set as a course of action or direction. A policy comes from upper management and applies to the entire organization.
- **Standard**—A standard is a detailed written definition for hardware and software and how they are to be used. Standards ensure that consistent security controls are used throughout the IT system.
- **Procedures**—Procedures are written instructions for how to use policies and standards. They may include a plan of action for installation, testing, and auditing of security controls.
- **Guidelines**—A guideline is a suggested course of action for using the policies, standards, or procedures. Guidelines can be specific or flexible regarding use.

FIGURE 1-10 is an example of a hierarchical IT security policy framework. Policies apply to an entire organization, standards are specific to a given policy, and procedures and guidelines help define use. Within each policy and standard, identify the impact for the seven domains of a typical IT infrastructure. Doing so will help define the roles, responsibilities, and accountability throughout the domains.

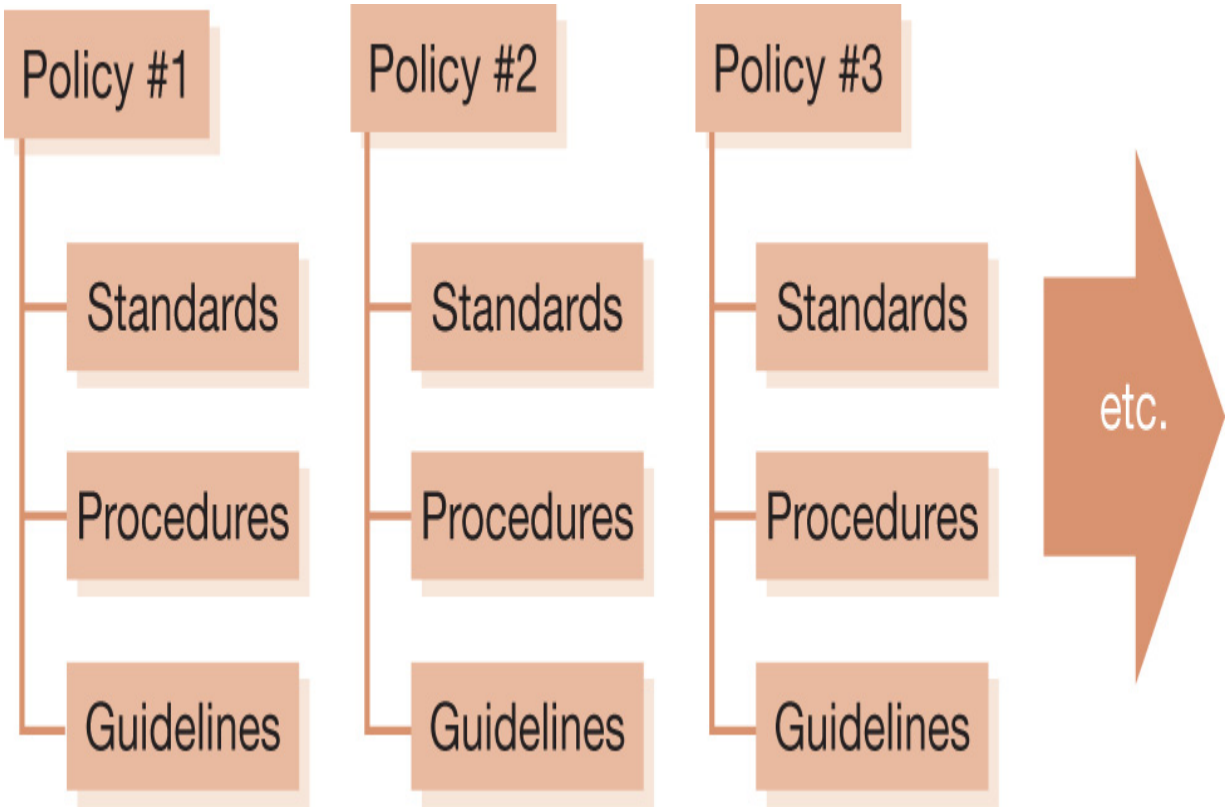


FIGURE 1-10 Hierarchical IT security policy framework

Foundational IT Security Policies

The focus of an organization's IT security policy framework is to reduce its exposure to risks, threats, and vulnerabilities. It is important to relate policy definition and standards to practical design requirements. These requirements will properly apply the best security controls and countermeasures. Policy statements must set limits as well as refer to standards, procedures, and guidelines. Policies define how security controls and countermeasures must be used to comply with laws and regulations.

Examples of basic IT security policies include the following:

- **Acceptable use policy (AUP)**—The AUP defines the actions that are and are not allowed regarding the use of organization-owned IT assets. The AUP is specific to the User Domain and mitigates risk between an organization and its employees.
- **Security awareness policy**—This policy defines how to ensure that all personnel are aware of the importance of security and behavioral

expectations under the organization's security policy. It is specific to the User Domain and is relevant when organizational security awareness behavior needs to change.

- **Asset classification policy**—This policy defines an organization's data classification standard. It designates the IT assets that are critical to the organization's mission as well as defining the organization's systems, uses, and data priorities and identifying assets within the seven domains of a typical IT infrastructure.
- **Asset protection policy**—This policy helps organizations define a priority for mission-critical IT systems and data. It is aligned with an organization's BIA and is used to address risks that could threaten the organization's ability to continue operations after a disaster.
- **Asset management policy**—This policy includes the security operations and management of all IT assets within the seven domains of a typical IT infrastructure.
- **Vulnerability assessment and management**—This policy defines an organization-wide vulnerability window for production operating system and application software. Organization-wide vulnerability assessment and management standards, procedures, and guidelines are developed from this policy.
- **Threat assessment and monitoring**—This policy defines an organization-wide threat assessment and monitoring authority. Specific details regarding the LAN-to-WAN Domain and AUP compliance should also be included in this policy.

Organizations need to tailor their IT security policy framework to their environment. After conducting a security assessment of their IT setup, many organizations align policy definitions to gaps and exposures. Typically, policies require executive management and general legal counsel review and approval.

Data Classification Standards

The goal and objective of a data classification standard is to provide a consistent definition for how an organization should handle and secure different types of data, which are protected through security controls that are within the seven domains of a typical IT infrastructure. Procedures and guidelines must define how to handle data within the seven domains of a typical IT infrastructure to ensure data security.

For businesses and organizations under recent compliance laws, data classification standards typically include the following major categories:

- **Private data**—Data about people that must be kept private. Organizations must use proper security controls to be in compliance.
- **Confidential**—Information or data owned by the organization. Intellectual property, customer lists, pricing information, and patents are examples of confidential data.
- **Internal use only**—Information or data shared internally by an organization. Although confidential information or data may not be included, communications are not intended to leave the organization.
- **Public-domain data**—Information or data shared with the public, such as website content, white papers, and the like.

U.S. Federal Government Data Classification Standard

The U.S. government, under Executive Order 13526, defines a data classification standard for all federal government agencies, including the DoD. President Barack Obama signed this executive order on December 9, 2009. Although the U.S. government and its citizens enjoy the free flow of information, securing information is essential for national security, defense, or military action.

The following points define the U.S. federal government data classification standards:

- **Top secret**—Applies to information that the classifying authority finds would cause grave damage to national security if it were disclosed.
- **Secret**—Applies to information that the classifying authority finds would cause serious damage to national security if it were disclosed.
- **Confidential**—Applies to information that the classifying authority finds would cause damage to national security.

Whereas public-domain information is considered unclassified, it is not part of the data classification standard. The U.S. government does have rules for handling unclassified (posing no threat to national security if exposed) and controlled unclassified information (for official use only, sensitive but unclassified, and law enforcement sensitive). Note that these rules are not included in Executive Order 13562 and were based on previous standards put into use by the administration of President George W. Bush.

Depending on the organization's data classification standard, data of the highest sensitivity may need to be encrypted, even in storage devices and hard drives. For example, you may need to use encryption and VPN technology when the public Internet is used for remote access, but internal LAN communications and access to systems, applications, or data may not require use of encryption.

Users may also be restricted from getting to private data of customers and may be able to access only certain pieces of data. Customer service reps provide customer service without getting to all of a customer's private data. For example, they may not be able to see the customer's entire Social Security number or account numbers, just the last four digits. This method of hiding some of the characters of the sensitive data element is called **masking**.

Technical TIP

Organizations should start developing their IT security policy framework by defining an asset classification policy. This policy, in turn, aligns itself directly to a data classification standard, which defines the way an organization is to secure and protect its data. Working from a data classification standard, you need to assess whether any private or confidential data travels within any of the seven domains of a typical IT infrastructure. Depending on how the data is classified and used, you will need to employ appropriate security controls throughout the IT infrastructure.

CHAPTER SUMMARY

This chapter introduced information systems security and the information systems security profession. A common definition for a typical IT infrastructure was presented as well as information about the risks, threats, and vulnerabilities within the seven domains, each of which requires the use of strategies to reduce the risks, threats, and vulnerabilities. You saw how IT security policy frameworks can help organizations reduce risk by defining authoritative policies. You also learned that data classification standards provide organizations with a road map for ways to handle different types of data.

KEY CONCEPTS AND TERMS

Availability
Carrier Sense Multiple Access/Collision Detection (CSMA/CD)
Certified Information Systems Security Professional (CISSP)
Cleartext
Confidentiality
Confidentiality, integrity, and availability (C-I-A)
Content filtering
Cybersecurity
Cyberspace
Data breach
Data classification standard
Downtime
End-User License Agreement (EULA)
Ethernet
FICO
File Transfer Protocol (FTP)
General Data Protection Regulation (GDPR)
Hardening
Hypertext Transfer Protocol (HTTP)
Hypertext Transfer Protocol Secure (HTTPS)
Identity theft
Information security
Information systems
Information systems security
Institute of Electrical and Electronics Engineers (IEEE)
Integrity
Internet
Intrusion detection system/intrusion prevention system (IDS/IPS)
IP default gateway router
IP stateful firewall
IT security policy framework
Layer 2 switch

Layer 3 switch
Local area network (LAN)
Masking
Network interface controller (NIC)
Network key
Protocol
Risk
Secure Sockets Layer virtual private network (SSL-VPN)
Security
Security control
Service-level agreement (SLA)
Smartphone
Software vulnerability
Telnet
Thick client
Thin client
Threat
Transmission Control Protocol/Internet Protocol (TCP/IP)
Trivial File Transfer Protocol (TFTP)
Unified communications
Uptime
Virtual LAN (VLAN)
Virtual private network (VPN)
Vulnerability
Vulnerability window
Wireless access point (WAP)
Wi-Fi
Wireless LAN (WLAN)
Workstation
World Wide Web (WWW)

CHAPTER 1 ASSESSMENT

1. Information security is specific to securing information, whereas information systems security is focused on the security of the systems that house the information.
   A. True
   B. False
2. When selling software, software manufacturers limit their liability using which of the following?
   A. End-User License Agreements
   B. Confidentiality agreements
   C. Software development agreements
   D. By developing error-free software and code so there is no liability
   E. None of the above
3. The _____ tenet of information systems security is concerned with the recovery time objective.
   A. Confidentiality
   B. Integrity
   C. Availability
   D. All of the above
   E. None of the above
4. A publicly traded company or U.S. federal government agency must go public and announce that it has had a data breach and inform the impacted individuals of that data breach.
   A. True
   B. False
5. Which security control would reduce the likelihood of an attacker's gaining unauthorized access to a user's login ID?
   A. VPN
   B. Two-factor authentication
   C. Encrypting all stored data
   D. Firewall

6. The _____ is the weakest link in an IT infrastructure.
   A. System/Application Domain
   B. LAN-to-WAN Domain
   C. WAN Domain
   D. Remote Access Domain
   E. User Domain
7. Which of the following security controls can help mitigate malicious email attachments?
   A. Email filtering and quarantining
   B. Email attachment antivirus scanning
   C. Verifying with users that email source is reputable
   D. Holding all incoming emails with unknown attachments
   E. All of the above
8. Which security control would be implemented to stop attackers from intercepting and reading sensitive email messages?
   A. An acceptable use policy
   B. A data classification standard
   C. An IT security policy framework
   D. A VPN for remote access
   E. Secure access controls
9. Encrypting email communications is needed when sending confidential information within an email message through the public Internet.
   A. True
   B. False
10. Using security policies, standards, procedures, and guidelines helps organizations decrease risks and threats.
    A. True
    B. False
11. A data classification standard is usually part of which policy definition?
    A. Asset classification policy
    B. Acceptable use policy
    C. Vulnerability assessment and management policy

D. Security awareness policy
E. Threat assessment and monitoring policy

12. A data breach typically occurs after which of the following?
    A. Unauthorized access to systems and application is obtained
    B. Vulnerability assessment scan
    C. Configuration change request
    D. Implementation of a new data center
    E. Implementation of a web application update
13. Maximizing availability primarily involves minimizing _____.
    A. The amount of downtime recovering from a disaster
    B. The mean time to repair a system or application
    C. Downtime by implementing a business continuity plan
    D. The recovery time objective
    E. All of the above
14. Which of the following is not a U.S. compliance law or act?
    A. CIPA
    B. FERPA
    C. FISMA
    D. PCI DSS
    E. HIPAA
15. Internet IP packets are to cleartext what encrypted IP packets are to _____.
    A. Confidentiality
    B. Ciphertext
    C. Virtual private networks
    D. Cryptography algorithms
    E. None of the above

CHAPTER 2
Emerging Technologies Are Changing How We Live

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THE INTERNET OF THINGS (IoT) is one of the latest Internet innovations driving today's connectivity and communications vision, and it amplifies many privacy, security, technical, social, and legal challenges. The Internet first brought global connectivity among computers and has since expanded to include devices of all types, big and small. This unprecedented level of connectivity has not only transformed the way people and businesses communicate but has changed many aspects of our daily lives. Today, users are "always on" and connected (i.e., *hyperconnected*) to the Internet. **Social media**, such as Facebook®, Twitter®, LinkedIn®, Pinterest®, Snapchat®, TikTok®, Google+®, and Instagram®, as well as other services and applications, drives real-time connectivity and communications and has changed the way people interact. The Internet today provides a medium for all types of personal and business communications, whether they be:

- **Voice over Internet Protocol (VoIP)**—Real-time voice communications between people, replacing legacy telephone service
- **Instant messaging (IM) chat**—Real-time chat messaging
- **Audio conferencing**—Real-time audio conference calling among multiple people
- **Video conferencing**—Real-time virtual meetings among multiple people
- **Collaboration**—Real-time document sharing and editing with audio-conference and video-conference calling among multiple remote people
- **Digital media**—Audio recordings, pictures, videos for social media uploading and sharing, or streaming on demand

The Internet has changed the way people and businesses communicate. Now, with the emergence of the IoT, comes a tsunami of devices that users want to connect to the Internet. This desire is driven by the expectation for near real-time access to things deemed important, including consumer products, household items, cars, trucks, traffic lights, building and facility sensors, industrial monitoring and control systems, and critical infrastructure device connectivity.

There are both advantages and disadvantages to the promise of the IoT. No doubt, the IoT is transforming the way we live, work, and play. Remember when you used to use the telephone to make a restaurant reservation? Now, you can do it online through social media. Remember having to meet with a travel agent to make travel plans and arrangements for a family vacation? Now, you can research and book your own family vacation online with access to real reviews and critiques from other vacationing families. Remember having to travel for a company strategy session or meeting? Now, you can collaborate remotely with real-time audio, video, and collaboration applications. All of these changes allow businesses to save money and time by not having to pay for travel to group meetings and enable individuals and organizations to carry on operations without face-to-face interactions that are not possible or are to be avoided for health reasons.

But the IoT also comes with five critical challenges that need to be addressed:

- **Security**—The Internet is already the Wild West, with plenty of bad actors and little law enforcement, yet there is an increasing demand to connect more things to it.
- **Privacy**—How can you control your personal data? Whose data is it? Who owns the intellectual property of personal information, data, and media? What is a privacy policy statement, and why is it important to you?
- **Interoperability**—How do we define standards and protocols such that all IoT-connected devices can communicate and be accessible?
- **Legal and regulatory compliance**—The IoT vision presents legal and regulatory compliance issues that typically have not kept pace with the speed of IoT implementations.

- **Emerging social and economic issues**—The countries of the world and their citizens must quickly learn to understand and overcome the political, environmental, and economic issues presented by the IoT vision.

Chapter 2 Topics

This chapter covers the following topics and concepts:

- How the IoT has evolved from the late 1990s to the present
- How the Internet transformed personal and business communications in a TCP/IP (Transmission Control Protocol/Internet Protocol) world
- What the effects of IoT will be on people and businesses and the way we live
- How businesses evolved from brick and mortar to e-commerce to IoT
- Why today's businesses need an Internet and IoT marketing strategy
- How IP mobility is helping to drive an IoT world
- How mobile applications impact businesses and consumers
- What the key issues created by the IoT are

Chapter 2 Goals

When you complete this chapter, you will be able to:

- Describe the evolution of the IoT from the late 1990s to the present
- Recognize the impact that the Internet and IoT have on human and business life
- Understand how brick-and-mortar businesses transform into e-business models with e-commerce and an IoT strategy
- Explain how IP mobility is driving IoT to include both personal and business environments

- Describe the impact mobile applications have had on how business is conducted
- List the new challenges created by the IoT

Evolution of the Internet of Things

The evolution and rapid growth of the Internet was made possible by the deployment of nationwide optical fiber backbone networks and similar high-speed global networks. Faster speeds and greater bandwidth deliver more opportunities for humans to interact with each other and the growing number of connected things. With high-speed networks now extending to the mobile user, the opportunities are limitless. Today's consumer and business users benefit from broadband connectivity, thanks to nationwide cellular and wireless Internet service providers (ISPs). Fueled by the growth of the optical fiber backbone infrastructure of the late 1990s, ISPs extended their reach by connecting to cellular networks throughout the world, which in turn led to a surge in connecting mobile endpoints, such as smartphones and tablets, and now an increasing number of devices are connecting to the Internet. Parents can keep an eye on their children or pets through a secure webcam connection monitoring their home or daycare center. They can receive alerts from a motion-sensitive camera when someone steps onto their front porch and even talk with the visitor via real-time streaming video and audio. Businesses are using the Internet to conduct secure transactions and meetings of all sizes. When pandemic concerns sent many workers home, the Internet provided a way to stay connected and productive. Vending machines are now equipped with a cellular phone network antenna for secure credit card transaction processing. Smartphones and tablets that are cellular or Wi-Fi connected can be equipped with secure credit card transaction software to allow vendors of any size to swipe payment cards from virtually any location. Rural health care services can be provided using telemedicine, secure video communications, and collaboration. Any device that can connect to the Internet can be accessed by the device's owner and provide untold value.

The term **Internet of Things (IoT)** was first used in 1999. Kevin Ashton, a British technology visionary, first used it to describe objects connected to the Internet—any type of objects. Mr. Ashton's IoT describes objects in the physical world connecting to the Internet and allowing for any-to-any

connectivity as long as the use is authorized by its owner. At the same time, radio frequency identification (RFID) was being implemented within supply chain management processes to track the movement of goods and their delivery. Today, the term *IoT* is used to describe how a wide variety of objects, devices, sensors, and everyday items can connect and be accessed. The original expectation was that the IoT would be driven by industry, but it has turned out that IoT's primary driver is the end-user consumer market. Doorbells, home security systems, home appliances, and even personal vehicles are now connected and driving consumer demand for more data and services. Connecting IP devices and other objects to the Internet is not a new idea, but the vision of what is possible with IoT is gaining momentum. The speed of IoT implementations is not slowing down. In fact, it is rapidly increasing, which is creating the issues and challenges described previously.

Technology and market trends laid the foundation for IoT and are driving where IoT is headed. The danger in this system lies in the fact that these drivers push development and connectivity ahead of the security, privacy, and regulatory compliance that might govern it. How can we protect all these IP-connected devices? Is it a good idea to connect all your objects and devices to the Internet? The following technology and market trends are drivers for IoT:

- **IP-based networking is globally adopted**—The Internet provides global connectivity for any user, business, or device.
- **Connectivity is everywhere**—Broadband Internet connectivity is provided free in many public areas and as a benefit for customers (e.g., bars, restaurants, and coffee shops) in cities globally.
- **Smaller and faster computing**—Smaller semiconductors and faster chips result in faster computing and smaller device sizes.
- **Cloud computing is growing**—Cloud services allow for faster and easier access to data and content than traditional centralized architectures.
- **Data analytics feed the growth**—Capturing and studying the analytics of what, how, when, and why devices connect and communicate on the Internet feeds analytics for enhancing service and performance.

The IoT provides an avenue for things to connect, and this connectivity encompasses both personal and business life. IoT applications are being developed and hosted in secure cloud infrastructures, which can support a one-to-many delivery model via the Internet. **Application service providers (ASPs)** are software companies that build applications hosted in the cloud and on the Internet. Users do not have to buy software and install it on their workstations or laptop computers; rather, they run the applications hosted in a cloud using a secure browser. This function is referred to as **Software as a Service (SaaS)** computing. **FIGURE 2-1** depicts the SaaS application delivery model.

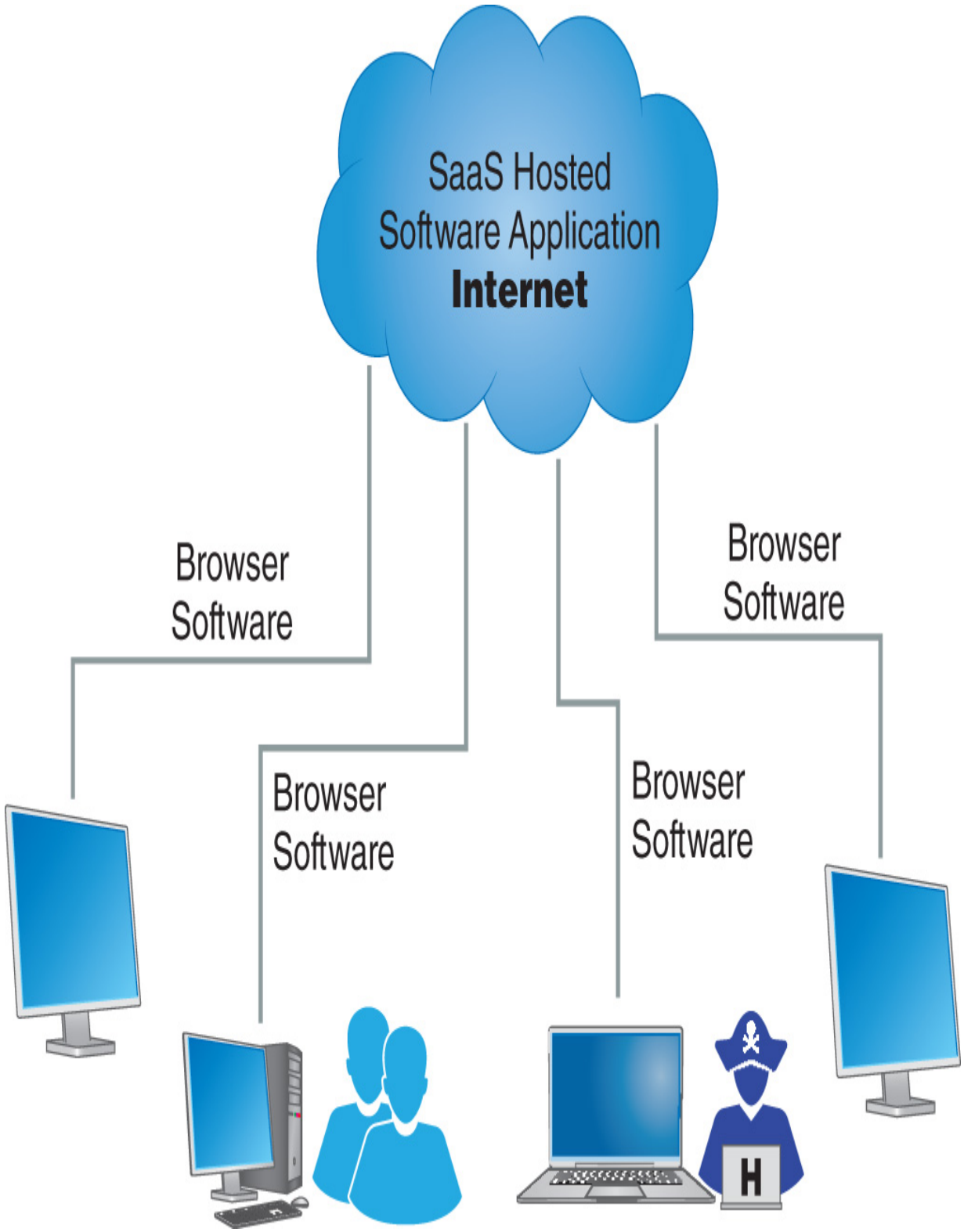
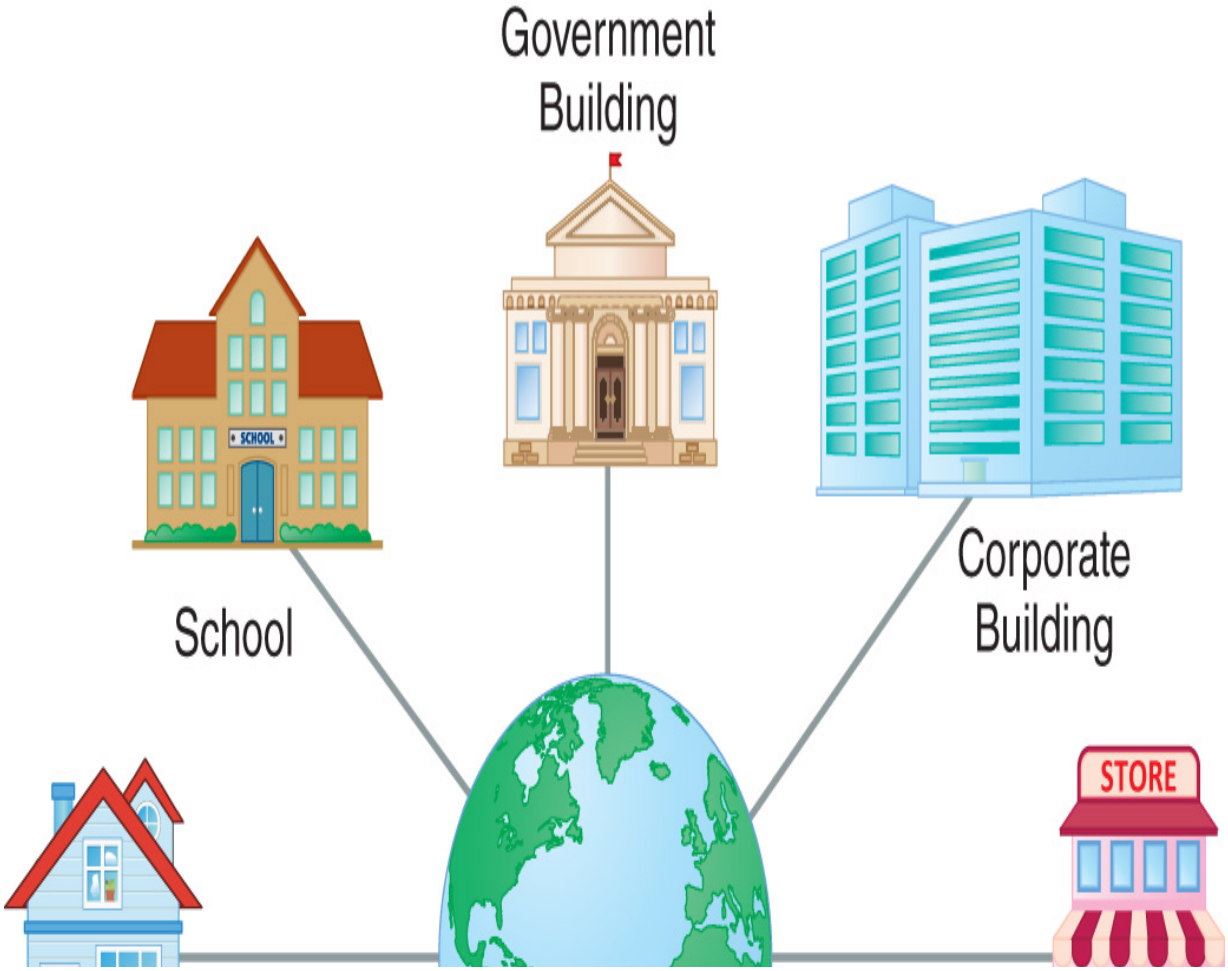


FIGURE 2-1 Software as a Service (SaaS) application delivery model.

With the growth in cloud hosting companies, such as Amazon Web Services (AWS), Microsoft Azure, and Google Cloud, came the growth in cloud application development. IoT applications for both personal and business scenarios were born. With ASPs building SaaS applications, new online e-businesses were born. The days of needing a brick-and-mortar storefront are gone. Today, a storefront on the World Wide Web is necessary, even if a business still has a brick-and-mortar presence. Without an online presence, businesses have no access to global users and suppliers. Internet marketing, having a World Wide Web presence, and maximizing **search engine optimization (SEO)** are important business requirements in today's IP-connected world.

Converting to a TCP/IP World

How did email become the foremost personal and business communication tool? And then how was it replaced by social media? How did iTunes®, Amazon Music, and Spotify become the leading online music distribution sites on the Internet? How did cell phones and the Internet impact the way we communicate? How did these changes affect businesses? The quick answer is that the transition to a TCP/IP world changed our way of life. People, families, businesses, educators, and government communicate differently than they did before, and nearly everyone has easy access to the Internet. Instead of physically visiting multiple locations or communicating via telephone, many transactions can occur online, via the Internet. **FIGURE 2-2** shows how the Internet and TCP/IP transform everyday life.



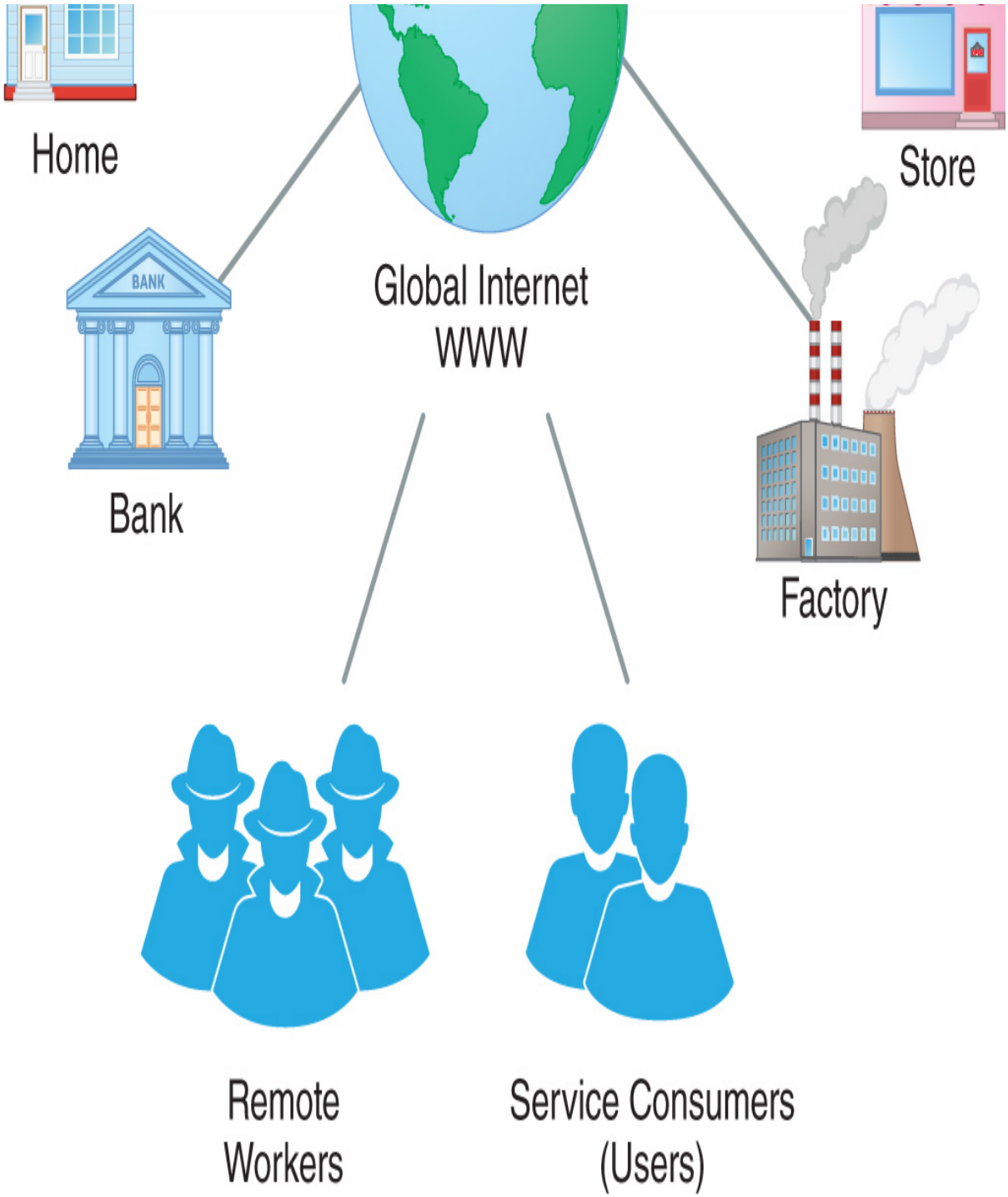


FIGURE 2-2 How the Internet and TCP/IP transform our lives.

IoT's Impact on Human and Business Life

People choose to use technology that connects to the Internet to provide a richer experience. This choice has transformed nearly every aspect of our day-to-day lives. When we awake, many of us reach for our smartphones to check the weather, the news, and social media sites (not necessarily in that order). When we get to the office, we check our business emails throughout the day and respond accordingly. With so much access to the Internet, remote workers find it difficult to separate home and office activities. Before the widespread use of the Internet—in the "dark ages," about 35 years ago—people seemed content to talk on landline telephones and watch TVs that used analog equipment. There was no World Wide Web to provide instant access to information. News was available in newspapers, on television (at certain times), or on the radio. To talk to people in real time, you had to get them to a landline telephone. The advent of pagers and voice-messaging systems helped with real-time access and with storing and forwarding information. Eventually, cell phones replaced pagers, allowing people to reach practically anyone, no matter where they were.

In the mid to late 1990s, as use of the Internet and World Wide Web became commonplace, access across the information superhighway began to change everyone's lives. People-to-people communication switched to the Internet, with commerce close behind.

How People Like to Communicate

Today, social media drives how we communicate with family members, friends, and business associates. It also strongly influences how we interact, make purchase decisions, and even think about issues. The prevalence of social media sharing (e.g., LinkedIn for professional contacts and Facebook for personal contacts) blurs the line between business and personal. Today's hyperconnected individual communicates in two basic ways:

- **Real-time communications**—When you need to talk to someone right now, **real-time communication** is the preferred mode, whether you are

reacting to a life-threatening situation; conducting financial transactions, such as buying stock or securities; or responding to a security breach. Real-time communication can also include scoped broadcasts to friends or acquaintances. Social media makes it easy to share a comment, video, or any type of message to a large number of people immediately. For many social media users, a "like" is as good as a response.

- **Store-and-forward communications**—When you do not need an immediate response from someone you choose to contact, **store-and-forward communications** may be used. Store-and-forward communication occurs in near real time. Voicemail and email are examples of store-and-forward communications, both of which store the message for later retrieval. Voicemail can even be converted into audio files and sent to your email inbox. This is an example of **unified messaging (UM)**, in which all of your messages (both voice and email) can be accessed via email.

IoT Applications That Impact Our Lives

Once the foundation for people-to-people communications was laid, IoT applications could be built on top of that. The following sections list examples of common IoT applications that can impact our daily lives.

The IoT's Impact on Humans

- **Health monitoring and updating**—Sensors can monitor human vital statistics and securely send data analytics to a bedside or mobile application. An increasing number of wearable devices can collect real-time health status information and communicate with apps to process and store it. New human IoT applications will provide near real-time monitoring of human performance (e.g., monitoring performance health indicators for athletes in training, tracking blood sugar levels for diabetics with a mobile application, or monitoring a patient's high cholesterol and submitting a recommended menu for what to eat that day).
- **Home security and smart home control systems**—Homeowners and renters can have real-time access to home security systems, access to home surveillance video camera feeds, and full control over home

heating and air-conditioning settings to maximize energy efficiency. Parents can even keep an eye on their children while they are away from home. Monitoring household use of water and energy, such as electricity and gas, can help with water and energy savings and help keep costs down.

- **Online calendars**—Families and friends can use tools to help plan shared rides and other activities that require coordination. These tools are especially vital if parents are acting as chauffeurs for their children during the school year. Family dinners, vacations, and children's transportation needs can be scheduled and coordinated more efficiently, and friends can plan meetings without having to engage in a round-robin string of telephone calls or emails.
- **Near real-time tracking and monitoring of friends and family members via global positioning systems (GPS)**—Parents concerned about where their children are can enable GPS tracking and monitoring through their smartphone and cellular phone service provider. GPS tracking and mobile applications provide parents with near real-time location finding of their children, using their smartphones as the tracking device.
- **Online banking, bill paying, and financial transactions**—Anyone can now automate many bill payments using online banking systems and applications via autopay deductions directly from their checking accounts. No more paper bills, no more writing checks, and no more mailing a payment through the postal delivery system. Today, most vendors and businesses accept secure, online e-payments, whether via an electronic checking account, credit card, or electronic wire transfer.
- **Online e-commerce purchases for household goods, food, and services**—Consumers have the ability to purchase goods and services online and pick them up at a retail store or have them drop-shipped to their front door. Online grocery stores now deliver groceries, providing maximum efficiency for on-the-go people who have no time to shop or who are practicing social distancing. Holiday shopping is done primarily online, allowing shoppers to avoid long checkout lines and stress at the shopping mall. Today, with government, businesses, and individuals moving to a completely online and digital world, individuals can interact and transact business from their homes or

places of business as long as they are connected to the Internet. Even ordering a pizza for home delivery has advanced to restaurants now providing delivery services for entire family meals delivered hot and ready to eat.

- **Automobiles with smart computers and always-on Wi-Fi Internet access**—Car shopping must-haves have evolved beyond miles per gallon and now include many advanced features and functions, such as:
    - Always-on Wi-Fi Internet access
    - Hands-free Bluetooth connectivity
    - LoJack® car locator
    - Remote control ignition starter
    - Automobile diagnostics that can be securely uploaded to the manufacturer before a car service appointment for preassessment analysis

The IoT's Impact on Businesses

Now that we know more about the impact that the IoT has on our day-to-day personal lives, what about the IoT's impact on businesses? The IoT is changing how businesses must sell and market their products and services. More important, businesses are looking for new opportunities the IoT brings. ASPs are the new wave of Internet startup companies providing IoT-based business products, services, and solutions. Cloud-based applications with mobile applications, with which end users can interact from their smartphones or tablets, are where IoT applications are headed. Here are examples of interesting IoT applications that businesses are beginning to adopt:

- **Retail stores**—Stores, banks, restaurants, and manufacturers must have an online presence directly to their customers. Coupled with an online catalog system and the ability to accept secure electronic payments, with self-pickup or delivery to people's front doors, customers can make purchases anytime from their Internet-connected smartphones, tablets, or computers. The cost to deliver goods and services is significantly reduced when consumers shop online. This change has created a paradigm shift from traditional brick-and-mortar retail stores

to online e-commerce portals. Customers can see and purchase products and services anytime, anywhere. Portals that have self-service are now supported with live instant messaging (IM) chat with a customer service representative while shoppers are on the website. Businesses can benefit from streamlined sales order entry linked directly to inventory management. The supply chain can be optimized throughout the manufacturing and distribution process flow given near real-time sales order access.

- **Virtual workplace**—Businesses and companies that are in the people or professional services business line do not need to come to a physical office unless it is for important meetings or presentations. Today, the IoT supports all communication types, including full two-way video conferencing and collaboration with colleagues who are located remotely or teleworking from home. Today's IoT provides working or single parents with an opportunity to be productive while at home, especially if they have childcare or other obligations. Workers can save time on commuting, maximize productivity, save on transportation and food costs, and collaborate effectively with colleagues. The ability to demonstrate presence and availability from remote locations has dramatically changed the way all of us interact. Health concerns, from local outbreaks to pandemics, may result in workers and students staying home. Virtual workplaces and schoolrooms make it possible to be productive without being physically co-located.
- **Remote sensors for utility, environmental, and infrastructure monitoring and facility automation**—All businesses that require monitoring or control of things such as electric meters, water usage, pH balance of water, carbon monoxide meters, or gas leak sensors can benefit from the IoT. Imagine having near real-time access to sensor and meter readings, especially if alerts or alarm indicators are exceeded for safety reasons. Any business involved in utilities, critical infrastructure, or environmental services can benefit from Internet-connected sensors and meter-reading devices. This access can replace the need for a human to physically visit the location and obtain a meter reading. In addition to just monitoring, IoT provides the building blocks to integrate automation into business functions to reduce reliance on humans to manage facilities, a process often called *facility automation*.

- **City and public service traffic-monitoring applications**—Smart cities can monitor and report on real-time traffic conditions and redirect traffic flow during rush-hour conditions with near real-time updates to mobile applications accessible to smart cars. Moreover, city parking garages can pinpoint available parking spots.
- **The IoT is transforming the business-to-consumer (B2C) service delivery model**—Companies are transforming the way they deliver customer service via the Internet. This B2C transformation is being led by new web and mobile applications that are providing online access to businesses' products and services. No matter what you need or want, businesses are transforming how they package, deliver, and sell it to you, the consumer. Remember going to record or CD stores? Now, since the advent of the digital revolution, there are no more record or CD stores; digital music distribution is now done online through various music distribution sites. Training companies have transformed in-person training courses into online e-learning delivery with videos, audio recordings, and student interaction, and training for consumer products is typically provided via a YouTube video, with step-by-step instructions showing consumers how to assemble a product. This type of customer experience is what the IoT is driving—a better, faster, more effective way to train customers on using a product or service. Using YouTube videos also brings the cost of delivery to nearly zero and increases the customer experience by providing fast and easy installation instructions for the product. IoT applications use the Internet to create an entire customer experience and offering, including a complete Internet and social media marketing campaign, with frequent-buyer coupons and incentives sent via email. Sales and other special services send near real-time Short Message Service (SMS) text messages for those who register online.
- **New Anything as a Service IoT applications**—As new IoT and mobile applications are being developed, businesses can implement the **Anything as a Service (AaaS)** delivery model, which allows them to transform themselves into an IoT service offering. AaaS means that whatever a business is currently doing can be transformed into a hosted, secure cloud solution where its content and information can be accessed from a website. Maintaining calendars; posting health care reminders;

shopping for groceries; or finding products or services, such as dry cleaning, babysitting, and tax preparation services, or anything, for that matter, are possible with the Internet. Businesses that can convert or invent new products or new services for IoT commerce will win the IoT as a service offering in tomorrow's environment.

The Internet Society

The Internet Society (*https://www.internetsociety.org/mission/*) has captured the human essence of the Internet in its vision and mission statements:

Vision: The Internet is for everyone.
Mission: The Internet Society supports and promotes the development of the Internet as a global technical infrastructure, a resource to enrich people's lives, and a force for good in society.
Our work aligns with our goals for the Internet to be open, globally-connected, secure, and trustworthy. We seek collaboration with all who share these goals.

Together, we focus on:

Building and supporting the communities that make the Internet work;
Advancing the development and application of Internet infrastructure, technologies, and open standards; and
Advocating for policy that is consistent with our view of the Internet.

To help achieve our mission, the Internet Society:

Facilitates open development of standards, protocols, administration, and the technical infrastructure of the Internet.
Supports education in developing countries specifically, and wherever the need exists.
Promotes professional development and builds community to foster participation and leadership in areas important to the evolution of the Internet.
Provides reliable information about the Internet.

Provides forums for discussion of issues that affect Internet evolution, development, and use in technical, commercial, societal, and other contexts.
Fosters an environment for international cooperation, community, and a culture that enables self-governance to work.
Serves as a focal point for cooperative efforts to promote the Internet as a positive tool to benefit all people throughout the world.
Provides management and coordination for on-strategy initiatives and outreach efforts in humanitarian, educational, societal, and other contexts.

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Evolution from Brick and Mortar to E-Commerce

The Internet changed more than how people communicate; it also revolutionized business. Brick-and-mortar businesses now have global reach. E-commerce has changed how businesses sell, and the Internet has changed how they market.

What is **e-commerce**? It is the sale of goods and services on the Internet, whereby online customers buy those goods and services from a vendor's website and enter private data and checking account or credit card information to pay for them.

E-commerce supports two business models: **business-to-consumer (B2C)** and **business-to-business (B2B)**:

- **B2C**—Businesses create an online storefront for customers to purchase goods and services directly from their websites, such as *www.amazon.com*.
- **B2B**—Businesses build online systems with links for conducting sales with other businesses, usually for integrated supply chain purchases and deliveries.

E-commerce systems and applications demand strict confidentiality, integrity, and availability (C-I-A) security controls. Organizations must use solid security controls to protect their information from all attackers on the Internet. This is especially true if private data and credit card information cross the Internet. To comply with the Payment Card Industry Data Security Standard (PCI DSS), businesses must conduct security assessments and use the correct controls to protect cardholder data. The Internet created a global online marketplace nearly overnight. No one foresaw such a large change—or the resulting impact. Once the Internet became ubiquitous, advertising, sales, and marketing were no longer confined to television, radio, newspapers and magazines, and direct mail. Marketing is about finding new customers, keeping them, and providing better goods and services, and the Internet made these activities possible with online convenience. But the

Internet has realigned business challenges, and these new challenges include the following:

- Growing the business through the Internet
- Changing an existing conventional business into an e-business
- Building secure and highly available websites and e-commerce portals
- Building a web-enabled customer-service strategy
- Finding new customers with Internet marketing

Companies such as Amazon, Dell, Apple, Western Union, eBay, Priceline.com, Domino's Pizza, and UPS have created e-business models, using websites as the main way to reach global customers. Their customers make purchases with enhanced customer-service delivery built into the websites, making self-service the name of the game and allowing customers to do many activities themselves online (account management, for example). Real-time access to customer service agents via VoIP and IM chat can enhance the experience for high-value customers.

What is an e-business strategy? It changes business functions and operations into web-enabled applications and includes marketing and selling goods and services on the Internet. An e-business strategy typically includes these elements:

- **E-commerce solution**—This might be an online catalog and system for purchasing goods and services in a secure transaction.
- **Internet marketing strategy**—Internet marketing strategies involve SEO, which uses embedded metatags and keywords to help search engines sort results; customer lead generation, in which marketers request customer information from information websites and white-paper downloads; email blasts, in which advertisements and discount coupons are emailed directly to prospects; and push marketing, which involves direct sales and marketing based on user interest.
- **E-customer service-delivery strategy**—This is a strategy for creating and maintaining a self-serve and online customer service.
- **Payment and credit card transaction processing**—Secure online payment and credit card transaction processing must be encrypted with

strict back-end system security controls to prevent unauthorized access to private customer data.

Why Businesses Must Have an Internet and IoT Marketing Strategy

Building an e-business strategy involves more than simply building a website. An e-business owner must understand how to find new business partners and new customers globally through the Internet. Without an e-business strategy or migration plan to get there, a business will lose to Internet-savvy competitors. An Internet marketing strategy is a key part of a business's success that entails getting more eyeballs to a business's website and keeping them there. Internet marketing strategies use search engine strategies, joint marketing agreements, and content that is fresh and in demand. Businesses must have an online e-business presence that provides customers with continuous access to information, products, and services, making brick-and-mortar business models out of date as the sole model in today's global market. **FIGURE 2-3** shows the process of transforming to an e-business model on the World Wide Web.

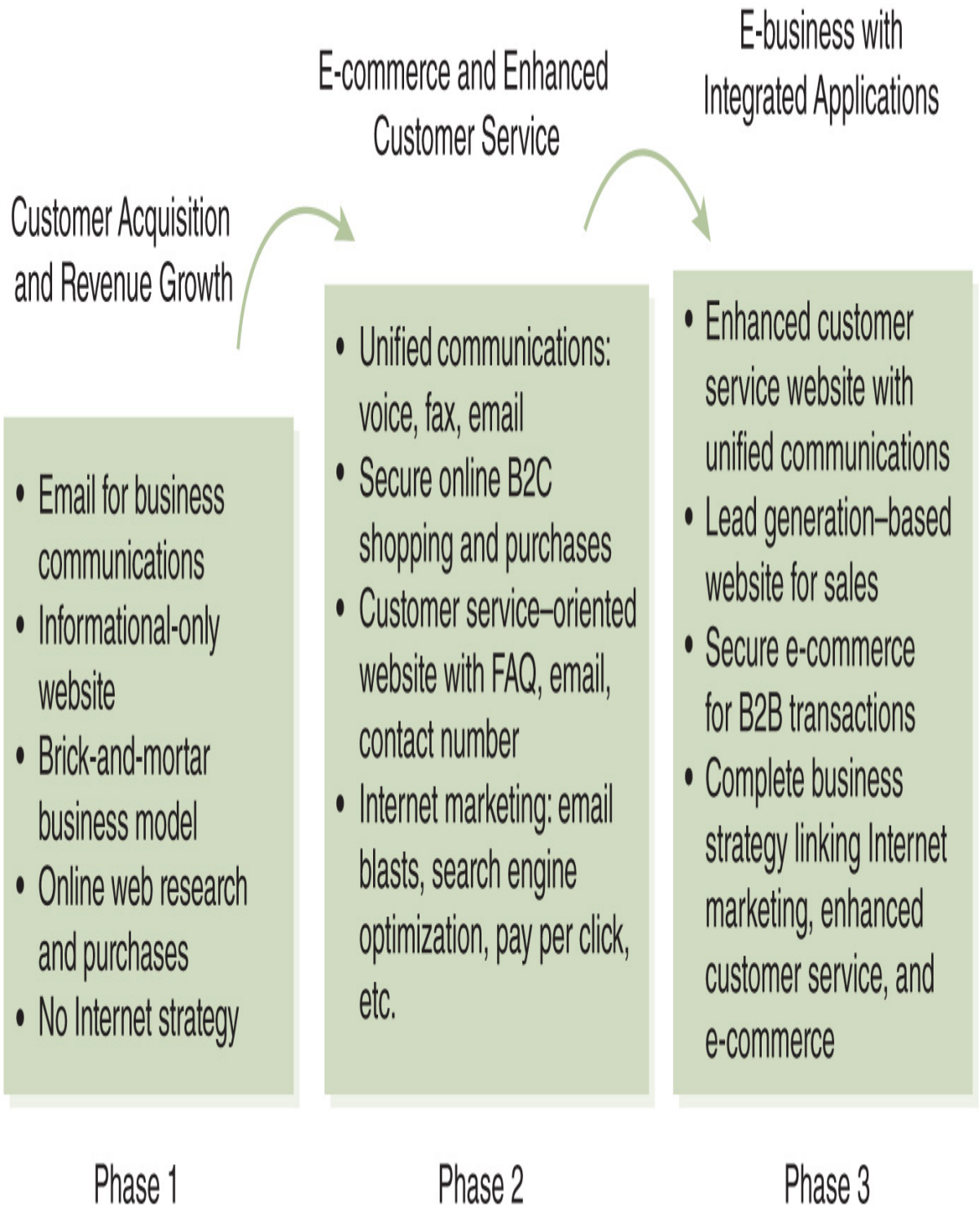

Customer Acquisition and Revenue Growth
E-commerce and Enhanced Customer Service
E-business with Integrated Applications
• Email for business communications
• Informational-only website
• Brick-and-mortar business model
• Online web research and purchases
• No Internet strategy
• Unified communications: voice, fax, email
• Secure online B2C shopping and purchases
• Customer service–oriented website with FAQ, email, contact number
• Internet marketing: email blasts, search engine optimization, pay per click, etc.
• Enhanced customer service website with unified communications
• Lead generation–based website for sales
• Secure e-commerce for B2B transactions
• Complete business strategy linking Internet marketing, enhanced customer service, and e-commerce
Phase 1
Phase 2
Phase 3

FIGURE 2-3 Transforming to an e-business model on the web.

As businesses include the Internet in their business models, they increase their exposure to online risks, threats, and vulnerabilities. Remember,

connecting to the Internet means exposing the company's assets, including its data, to hackers and cyberthieves. Secure web applications, secure front-end and back-end systems, and encryption of private customer data are critical security controls that each organization must implement to reduce risk.

This is not to say that brick-and-mortar stores are not needed or are wholly obsolete. Almost ironically, the massive online store Amazon quietly opened its first real-world retail presence in late 2015. Purported plans to open several hundred more brick-and-mortar stores in upcoming years speak to how brick-and-mortar stores will continue to coexist with an online e-commerce presence and the overall customer experience. And, even if Amazon.com never opened a physical store, the company has many massive warehouses and shipping centers worldwide, indicating that even online business requires physical facilities to operate.

IP Mobility

Communication devices have changed as much as the techniques people use to communicate. Previous changes to communicating involved adopting newer computers and connecting to networks. Voice communication generally occurred using telephones, and, for many years, telephones did little more than support voice communication. Over the past several years, though, personal communication devices and mobile phones have become very powerful. Use of cell phones exploded in the 1990s as people began to use them to extend their mobility. Today's smartphones, tablets, and wearable smart devices have grown to match the power and flexibility of many small computers, and in response software publishers have developed many programs targeted for the portable device market. Tablets, smartphones, and ultra-lightweight laptops, which a growing number of people carry instead of larger laptops for everyday use, have emerged to fill a need for easily portable devices.

Mobile Users and Bring Your Own Device

One of the big trends affecting organizations of all sizes is the growing use of personal communication devices because, as users came to rely on their personal devices, employees came to expect to maintain connectivity while at work. Organizations able to permit the devices still had to employ some control over their use through a policy that popularly became known as **Bring Your Own Device (BYOD)**. Organizations with such a policy can allow their employees and contractors to use their own personally chosen and procured devices to connect to the network at their office, a practice that often replaces the need for the organization to procure limited model options and issue them to employees for individual use. However, some advisers will support the "business sense" of such a move as it relates to lower purchase price, lower operational costs, and supportability of users and applications, whereas others recognize that BYOD opens the door to considerable security issues.

Users want small devices that are multifunctional and connected. To fulfill this demand, over the past two decades, laptops have gotten smaller, lighter, and more powerful, so powerful that they can match the performance of many desktop computers. Users then began to rely on their laptops to enjoy the mobility of taking work away from their desks as well as enjoying being able to leave their offices and still be connected to email and a growing number of office applications. From this development, the user community began to expect mobility and freedom from desktop computers, and, in turn, computer manufacturers began to offer even smaller, lighter, and more powerful laptops to appeal to a growing consumer desire to be connected everywhere, without having to carry a heavy device around.

Smartphone, tablet, and other mobile device manufacturers paid attention as well. They began to make their devices faster and more powerful—more like a computer. One of the early leaders in increasing market share among business users was BlackBerry, which released its first device in 1999. It allowed users to use a single device to make phone calls, access email, and manage schedules as well as run some applications and perform some of their work without a laptop. Apple followed with its iOS products, starting with the popular iPhone®, the first of which was released in 2007. Then in 2008 followed the first Android phone, the T-Mobile G1™, using the brand-new Android operating system. With these three heavy hitters in the market, the race was on to win the most mobile users.

The question at that time was, "Who really wants to use mobile devices?" The answer resoundingly was, "Almost everyone!" People wanted mobile devices for their personal and professional lives, and this trend pointed to the importance of BYOD. The supply of mobile devices, software, and services barely kept up with demand as mobile users discovered more and more uses for mobile technology with each new device or software release. Mobile computing began to approach the power and convenience of traditional computing, but at least three issues still remained: network speed, usability, and security.

There are many uses for mobile devices and applications. Some of the earliest applications were really just lightweight web apps whereby users connected to the web server using a limited-capability browser on their mobile device. Later, smartphones supported native applications that did not require continuous network connections. Whereas some applications must be

connected at all times, others do not need to be, an example of which is one that stores employee timesheet information on a central server. The mobile device must connect to a network to synchronize data with the server but does not need to maintain a constant connection. Applications that do not require continuous network connection make it possible to work with mobile data, for example, on an aircraft or in other remote locations.

One of the earliest uses of mobile devices was to take work away from the workplace, and thus mobile workers quickly became the drivers for migrating applications to mobile devices. Some of the first applications that were made available were those that helped manage email and schedules. Medical professionals also quickly realized the advantages of mobile computing for managing medical information. To provide the best treatment, medical personnel need to be able to quickly access patients' charts and files, filled with their private medical information. Therefore, hospitals, clinics, and practices have invested substantial amounts of time and money in managing patient data. The recent push to store medical records electronically makes accessing this data even more important. Moreover, mobile devices have made it possible for doctors, nurses, and other authorized medical personnel to access and update patient records on demand.

Mobile Applications

Many organizations tried to meet the needs of new mobile user demands by simply enabling their applications for the web, but most mobile devices included only limited web browsers and could run just a few applications. This approach opened many applications to users who could previously access the applications only by using in-house computers, but, unfortunately, functionality often suffered. Applications that were not written for web browsers often ended up being confusing and frustrating for users, and many applications failed due to bad interface designs for mobile users.

Once mobile device manufacturers, software developers, and service providers began to support mobile users, the main questions they began to ask were, "Who is using mobile applications?" and "Who wants to use mobile applications?" They found that many users from multiple domains found uses for mobile applications and that medical personnel were among the most aggressive early adopters.

Medical applications were a good fit for mobile applications from the early days of mobile devices because medical personnel need to interact with patients and their data continually. For example, hospital patients may see several doctors, nurses, and other practitioners each day, making it necessary for each medical staffer they encounter to have access to some of their information, which can include demographics, history, diagnosis, and treatment, to provide appropriate care. Because it is difficult and expensive to place a computer in every room, medical practices and hospitals realized early on that mobile devices could provide the ability to grant access to the necessary information without having to make investments in many computers and network infrastructure; each caregiver could carry a mobile device and have easy access to the required information on demand.

IP Mobile Communications

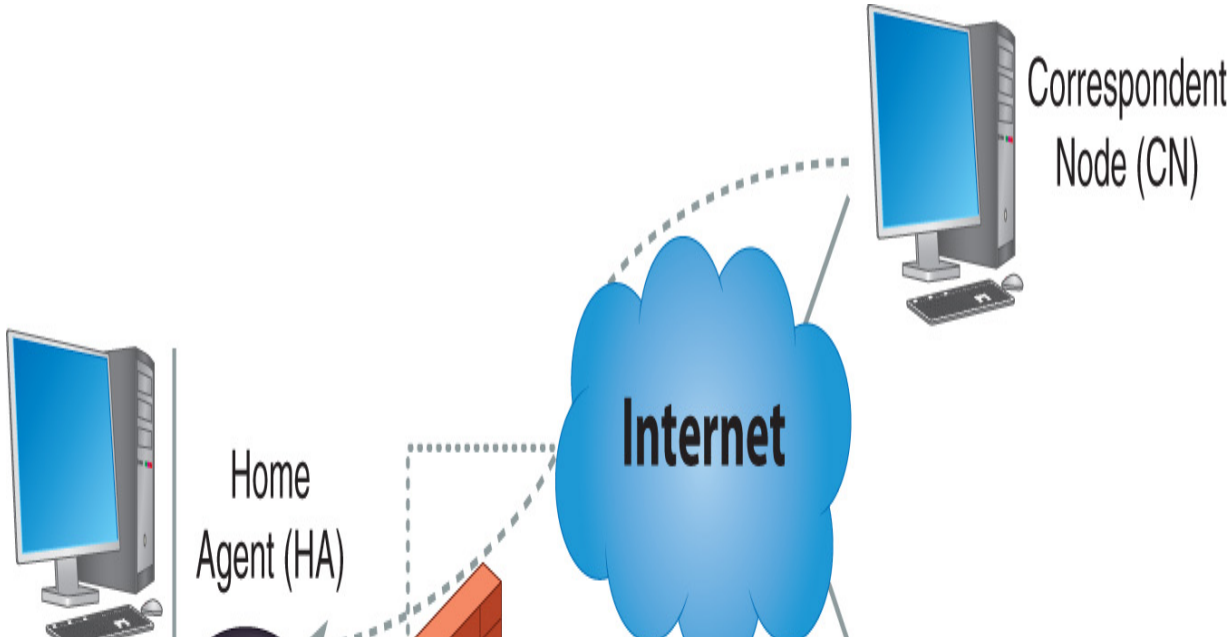
Today's 4G and 5G networks, which represent a significant improvement over previous technologies, provide true IP communications. Each 4G/5G device has a unique IP address and appears just like any other wired device

on a network, an attribute that allows mobile devices to interact with any other IP device without having to translate addresses. The only limitation on capabilities is in the processing power of the mobile device; however, as mobile devices become faster and faster, the differences are decreasing.

Mobile devices can now operate like wired devices, without being restricted by a physical boundary, and this fact represents both an advantage and a potential danger. Traditional network management is often based on the knowledge of where devices are located; therefore, devices that move around freely can be more difficult to track down, let alone to secure.

Moreover, mobile users want to connect to networks just as if they were physically plugged into the network in their office, and now they can through **Mobile IP**. Using Mobile IP, users can move between segments on a local area network (LAN) and stay connected, without the interruption that would normally happen using standard TCP/IP, and not even realize when their devices jump from one network to another as they move about. Users can maintain a connection to the network as long as their mobile device stays within network coverage, and the network device can switch between cellular and Wi-Fi and still provide transparent connections.

FIGURE 2-4 demonstrates how Mobile IP provides connection transparency for several entities working together to ensure that mobile devices can move from one network to another without dropping connections:



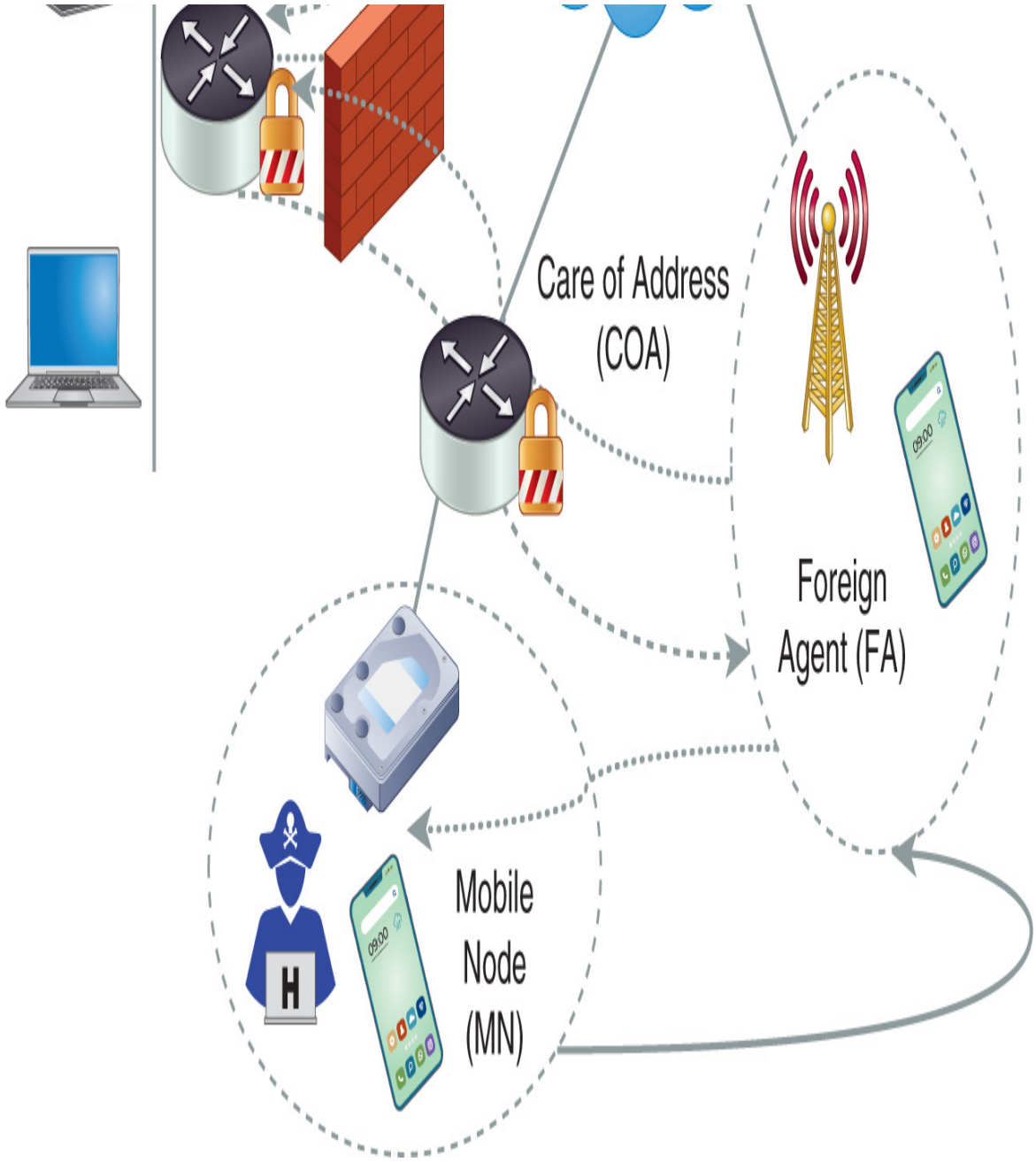


FIGURE 2-4 IP Mobile Communications:

1. Mobile node (MN) connects to foreign agent (FA).
2. FA assigns care of address (COA) to MN.
3. FA sends COA to home agent (HA).
4. Correspondent node (CN) sends message to MN.
    1. CN's message for MN first goes to HA.

2. HA forwards message to COA.
3. FA forwards message to MN.

- **Mobile node (MN)**—The mobile device that moves from one network to another. The MN has a fixed IP address regardless of the current network.
- **Home agent (HA)**—A router with additional capabilities over standard routers that keeps track of the MNs it manages. When an MN leaves the local network, the HA forwards packets to the MN's current network.
- **Foreign agent (FA)**—A router with additional capabilities connected to another network (not the HA network) that assigns the MN a local address. When the MN connects to another network that supports Mobile IP, it announces itself to the FA.
- **Care of address (COA)**—The local address for the MN when it connects to another network. The FA assigns the COA to the MN and sends it to the HA when the MN connects. In many cases, the COA is actually the FA address. The HA forwards any packets for the MN to the COA. The FA receives the packets and forwards them to the MN.
- **Correspondent node (CN)**—The node that wants to communicate with the MN.

Suppose an MN leaves the home network and connects to another network. When the MN connects to a new network, the FA sends the COA to the HA. Then, a CN wants to communicate with the MN, so the CN sends a message to the MN's IP address. The network then routes the packet to the MN's home network. The HA receives the packet and forwards it to the COA, after which the FA forwards the packet to the MN.

New Challenges Created by the IoT

In the introduction to this chapter, you learned about the five key challenges that the IoT must overcome:

- **Security**—How do you keep the bad guys out if you enable the IoT for your personal and professional life?
- **Privacy**—How do you protect your personal identity and private data from theft or unauthorized access, which can lead to identity theft?
- **Interoperability and standards**—How well do IoT manufacturers and ASP developers ensure that devices communicate securely?
- **Legal and regulatory compliance**—What role do the international, federal, and state levels contribute toward legal, tax, and regulatory requirements regarding IoT-related business transactions that involve payment for goods and services?
- **E-commerce and economic development issues**—What are the economic rules of engagement for conducting business on the World Wide Web? How is IoT connectivity and information sharing to be deployed globally?

Security

Remember, the security triad consists of confidentiality, integrity, and availability (C-I-A). What if a business or an individual connects something, such as smartphones and IoT devices, to the Internet without security in mind? What if there is nothing of value or of a sensitive nature to steal on these devices; should they still be connected? What should a user or a business do before connecting to the Internet? Even though IoT devices may seem to be of little security value, these same questions hold true for them as well. You, the user, are the owner of your assets and the information contained in those assets, so it is critical that you decide what is at risk if you connect your personal life, home, and business content to the Internet. You have to have a high degree of trust to connect your identity, social and family

life, home, and professional life to the Internet, or you have to have a high degree of trust that you can enable your own security controls as a defense strategy for connecting your assets to the IoT. Regardless of your defense strategy, there are risks, threats, and vulnerabilities everywhere. So where does trust come into play? As an individual user of the Internet, do the same human protocols and human etiquette apply online? What is acceptable or unacceptable behavior, and who or what organization defines what is acceptable or unacceptable?

The Internet is already filled with hackers and bad actors, and security and data breaches are occurring every day. Each day, more and more people and businesses want to connect devices via the IoT phenomenon. There are more Internet-connected devices and people, businesses continue to expand their online presence, and new applications are being developed and distributed via the Internet. Moreover, software products and distribution are no longer done via CD or DVD; today, once you purchase a software license online, you can immediately download the software and install it on a device. People are becoming more dependent on their electronic devices and real-time connectivity, which is increasing their level of dependency on Internet connectivity and IoT device access. As people and businesses become ever more dependent on the IoT, the opportunities for bad actors to attack, steal, and damage will increase, which is why security is the greatest challenge for the IoT to overcome. Moreover, security entails global issues that affect all people, governments, and businesses. Therefore, who will act as the governing body, and what policies and procedures or code of conduct should people and businesses abide by when interacting with the IoT?

Here are some of the most important security challenges of IoT devices:

- IoT devices, such as sensors or consumer items (e.g., Internet-connected TVs and other appliances), are deployed in large quantities. Depending on the criticality of the application, an outage could impact many endpoints if attacked.
- IoT devices are ubiquitous and can have wide reach into the user or household population. For example, electrical meters that are Internet connected introduce a critical infrastructure vulnerability if an attack could be replicated and pushed to individual endpoints.

- IoT devices that are not updated or maintained properly may permit vulnerabilities to become entry points into the network or organization. This is the equivalent of a vendor announcing an **End of Life (EOL)**, also called an *End of Service Life (EOSL)*, support timeline for a product or software application.
- IoT upgrades can be difficult to distribute and deploy, leaving gaps in the remediation of IoT devices or endpoints. Vehicles that have Wi-Fi access and onboard computers require software patches and upgrades from the manufacturer. This maintenance must be performed for all cars requiring the upgrade to remediate a software vulnerability.
- IoT devices typically do not provide the user or owner with any internal visibility or knowledge of how the device works and connects to the Internet. Vendors or service providers that have remote access to an IoT device may be able to pull information or data from your device without your permission. Review of the product warranty and IoT communications and data sharing with a service provider may be part of your use agreement.
- IoT devices typically are not physically secure and can be located anywhere in public areas or outside your house. Your home's electrical panel, cable TV, or fiber-optic cable points of entry are typically not that secure. Security is lacking for Wi-Fi–connected IoT devices on public or open Wi-Fi networks. IoT devices can be secured, but, to make them as easy to use as possible, manufacturers ship nearly all IoT devices with *weak defaults*. Weak user ID, password, and configuration defaults expose new IoT devices to attack but make them simple to connect to an existing network.
- Environmental IoT devices are typically out in the open capturing readings and measurements for scientific or research reasons. If an IoT device can act as a point of entry into an IP data network, a vulnerability in one device is compounded if there are many IoT devices out there.

Privacy

How do you protect your personal identity and private data from theft or unauthorized access that can lead to identity theft? Do you even know what

your privacy rights are as an individual living in your state and country? Are those same privacy rights extended to the Internet and IoT devices? Who owns the data in your IoT devices? **Privacy** has many layers, and it is often confused with confidentiality. Confidentiality is about the data, whereas privacy is about the individual. Protecting privacy means protecting any data that could identify you as a unique individual. Your first concern should be protecting your own personal privacy and then extending privacy to your spouse or other family members. Families require a privacy strategy to ensure that all family members' private data is kept confidential. Leakage of one family member's private data may be the opportunity for other family members' private data to be compromised.

Users must have a level of trust to use the Internet and IoT devices. More important is that their privacy is respected. Users' rights and private data must be clearly defined for all IoT devices. The IoT is creating new concerns for privacy and what private data is and who owns that data. Data that used to exist only inside a home, such as when the thermostat gets changed or how often the refrigerator needs a new filter, is now often willingly published on the Internet. As users embrace the IoT's conveniences and publish more and more private activity, the boundary of privacy gets more and more blurry. Who owns the actual data within an IoT device, the owner of the device (you) or the manufacturer? What about **metadata** of the data itself? Does metadata belong to the owner of the IoT device or the manufacturer that is collecting it via the Internet, as defined in the warranty and software license agreement that is assumed when the device user purchased the product? Metadata about the use patterns and information about the IoT device are beneficial to the manufacturer. But is this data yours? The definition of data and who owns it must be clearly understood before you purchase and connect the device to the Internet.

The IoT introduces new and interesting privacy challenges. These challenges must be fully understood and vetted by both the manufacturer of the IoT device and the individual user of that device. The following privacy challenges must be addressed by manufacturers and defined in the right-of-use and software EULA:

- **Privacy policy statement**—An actual legal definition of the user's privacy rights as documented in the manufacturer's privacy policy

statement. This privacy policy statement must accompany any online form where privacy data is input by an individual.

- **Definition of data, metadata, or analytical data use and rights**—This is an actual definition that defines what data, metadata, or analytical data is and what it may be used for and whether permission is required by the user for use of that data.
- **Ability for a user to provide consent to a manufacturer's or application service provider's privacy policy statement**—Users must be able to read the statement online and accept or decline the privacy policy's terms and conditions. Once a user provides consent, it is typically more painful to remove that consent. Some companies make you write a formal written removal of consent with no online capability.
- **Determine the domain of privacy**—If you permit geolocation tracking of you and your smartphone or IP mobile device and another ASP uses that information about you and where you go, is that infringing on your privacy rights? What if you did not even know that data was being collected? Invasion of privacy in your own home makes sense, but does that extend to the IoT devices within your home that are Internet connected? Domains of privacy become blurred when your privacy data or metadata is aggregated or correlated with other data to create new data. Remember, IoT devices can collect information about people with granular specificity. Data profiles can be created, thus creating new threats and patterns of behavior that you, the owner, may not want leaked or used by another party.

FYI

What if you are a health enthusiast and you subscribe to an online calorie and health performance tracking service via a mobile application? Your refrigerator, which is IoT connected, along with your online grocery store purchases, work together to track what you are eating and convert it to calories. You also decide to link the online restaurant reservation system you use to your calorie and health performance tracking application. When you order at a restaurant, the food and calories are automatically calculated into your daily calorie calculator. On top of all that, your IoT

fitness calorie monitor feeds real-time updates to your online calorie and health performance tracking application as you exercise and burn calories. The calorie and health performance ASP that hosts your calorie and health performance data performs analytics on your data and creates new metadata about your data. This metadata is sold to health care researchers or manufacturers of healthy foods. If they include demographics, such as your age, weight, and geographic location, they have a lot of information about you, even though it is considered **de-identified data**.

This concern about who owns the metadata, or data about the data, is very common within the privacy domain and is probably the number one privacy challenge that has yet to be fully explored and understood. In general, people do not know their privacy rights, but it is important that they do. This introduces a fine line between what users are comfortable doing and how much trust they have in the manufacturer of their IoT device.

In addition to these privacy challenges, the following questions are presenting new areas for exploration and understanding among IoT legal experts and privacy consultants:

- How do we address the data source and the data collectors' rights and use of data?
- Is there a happy medium that includes de-identification of private data, with no ability to link that data to a person?
- How will an individual or business even know what a good privacy posture or preference is?
- Will current social contexts and acceptable behavior extend to the IoT?
- Can we develop privacy by design (with a set of core requirements) and implement a standard of privacy for all of the IoT?

Questions like these require careful analysis and risk-mitigating solutions, especially from a legal and regulatory compliance perspective. U.S. federal and state privacy laws are meant to protect the private data of citizens while

requiring entities that use, handle, store, and transmit private data to abide by certain security and privacy requirements.

Interoperability and Standards

Interoperability and standards are key to implementing a consistent IoT device, connectivity, and communications environment. Without them, ASPs, IoT device manufacturers, and customers would be discouraged from implementing and connecting IoT devices. ISPs and end-user customers adopted the use of TCP/IP to ensure interoperability for end-to-end IP communications. Following a common theme of interoperability and standards for IoT device connectivity, security is critical to ensure device-to-device functionality. As long as the Internet Engineering Task Force (IETF) is involved, interoperability and standards can be pursued for IoT solutions. Following the Internet Society's four fundamental principles—connect, speak, share, and innovate—is key to driving the success of IoT innovation.

A fully interoperable IoT environment is desired to allow any IoT-connected device to talk to another IoT-connected device. This communication can occur either directly or indirectly through a shared server or application acting as a central point of communication. The key here is, how is information being collected, stored, and used? Interoperability requires similar operating systems (OSs), communication protocols, and methods for transmitting data in a secure manner to a server or application server hosted in a secure cloud. Standardization and adoption of common protocols and transmission schemas, including encryption and decryption, are important requirements that require standardized implementations.

Interoperability has significant financial impacts if not properly addressed, which is something that manufacturers and application software vendors do not want. They want to bring down the cost of IoT devices and applications that support IoT devices to a point that they are affordable for general consumers given the masses of users and businesses that can benefit from the IoT. Interoperability drives down the cost of IoT implementation for users and businesses. Implementation of open standards and interoperability requirements will allow for more IoT devices to connect, which increases the economic value, or return on investment, for IoT deployments because benefits are derived to pay for the cost of IoT deployment.

Interoperability, standards, protocols, and definitions are needed for early development and implementation of IoT devices. Following are the key challenges that must be addressed with interoperability and standards:

- **Some manufacturers want to design and deploy proprietary IoT devices and solutions**—This is a strategy to lock in early adopter customers and businesses to their own solutions, which creates technology silos that do not permit information sharing and require a gateway or intermediary solution to share information. If the data is in a shareable format, it is possible for applications to share IoT device data. Application programming interfaces (APIs) or other software interfaces may be needed for noncompatible IoT devices and applications to share information between them, a fact that hinders the implementation and acceptance of IoT.
- **Cost factors to implement functional, operational, technical, and security capabilities into IoT devices and applications**—Cost is always a key consideration in designing and implementing an IoT go-to-market strategy. Price points must be low and affordable, knowing that the masses will drive volume purchases for IoT device connectivity. Vendors and manufacturers must weigh the cost of interoperability into the IoT device itself versus getting the product out in the marketplace with immediate adoption.
- **Time-to-market risk**—There is no doubt that a first-to-market advantage exists for the global-scale IoT device marketplace. Vendors and manufacturers have been playing this game ever since technology was invented. How fast you get ahead of the interoperability and standards curve is based on where most of the user and business community is regarding use of proprietary or open standards–based IoT technology deployments. Without a time-to-market stress point, there would be no issue of going out on a limb regarding building and releasing product before interoperability and standards can be globally adopted and accepted.
- **Technology outdated risk**—Each IoT vendor, manufacturer, and software developer takes risks when developing IoT technical solutions and products without interoperability and standards definitions fully defined and adopted. This situation forces an early design to use open

and widely available standards or proprietary solutions and techniques. Obviously, the more open and flexible the architecture, the easier it is to adapt and alter technical interoperability and standard technology decisions during the design phase of IoT device and solutions development.

- **A void in interoperability and standards for IoT devices can create an environment of bad IoT devices**—Without interoperability and standards among IoT devices, there will be a lack of communication and information sharing. It may cause multiple IoT environments in which the devices may not be able to communicate or share data, which then creates more issues with multiple IoT devices and IoT disparate networks that only those devices can connect to and share information with. What is the point of the IoT vision if the devices that connect do not communicate and share information with one another? Herein lies the ultimate challenge for IoT interoperability and standards adoption. Configuration updates must be automated, simple, and fully interoperable among IoT devices. Without an ability to send updated firmware, OS software, and other IoT device software, devices will become outdated, which will increase the risk of having vulnerable or outdated IoT devices connected to a production IP network. A remote configuration capability is what can drive interoperability and standards for all IoT devices and systems.

Legal and Regulatory Issues

The deployment of IoT devices on the public open Internet introduces immediate concerns from a regulatory and legal perspective. Some of these concerns have never existed before. With regulatory compliance throughout the United States now in full effect for many vertical industries, how are users and businesses to deploy IoT-centric devices and solutions in a compliant manner, especially for those vertical industries under a compliance law such as HIPAA for health care, FERPA for higher education, FISMA for the federal government, the Federal Financial Institutions Examination Council (FFIEC) for banking and finance, PCI DSS v3.2.1 as a standard to follow for secure credit card transaction processing, and the European Union's General Data Protection Regulation (GDPR)?

With regulatory compliance, we are concerned about properly handling sensitive data and ensuring its confidentiality. Sensitive data is uniquely defined for users and individuals under these compliance laws, but what about the data of IoT devices, which use the Internet to communicate? Depending on where the server or IoT application resides, the IoT data is traversing physical networks and crossing state boundaries. That means that private data is subject to the privacy laws of the state in which the user lives as well as the state in which the IoT hosting company resides (the same principle applies to international boundaries). It is this movement of data that can quickly cause a legal issue. If the IoT data is classified to be private or sensitive data protected under regulatory compliance, that IoT vendor or solutions provider is required to adhere to security control requirements and data protection laws as needed. This cross-border data movement is not new to the Internet, but what is new is that IoT devices can share and communicate IoT device data to other systems and applications without the user's authorization or knowledge. This complicates the privacy issue because the data can at times cross state borders without the user's knowledge or approval.

Who is collecting your IoT device data? Who is collecting your behavior patterns throughout your IoT devices? What is the collector doing with your IoT device and behavior data? This is a brand-new legal and privacy issue with IoT data discrimination. The data collected from your IoT devices tells a specific story about you and your use of that IoT device. This data can be used for your good as well as against you in a discriminating manner. Depending on the third-party right-to-use clauses, IoT vendors and ASPs may be using your data or metadata in a manner that may be discriminatory toward you. The data can even include information about where you travel or eat and what you do for entertainment. Metadata can be accumulated and sold to other companies seeking demographic marketing data about you and your spending habits. How valuable is this information to the other company? Does the IoT or device-tracking application vendor have the right to sell your metadata information? When engaging globally with other individuals from other countries, which laws apply to that person's privacy such that security controls may or may not be required?

Finally, what about IoT device liability? What if your IoT device is used for health care monitoring and alerts and alarms, but there is a malfunction?

If someone is injured or dies as a result of a faulty IoT device, does the limitation of liability come from the IoT device manufacturer, the ASP, or whom? Manufacturers have no way of knowing how that IoT device will be used by the owner. What if that device is used to commit or aid in a crime or robbery? If a hacker can compromise a home IoT security system and video camera system and then rob that house while the owners are away, who is liable for this actual robbery and loss of possessions? What if an IoT device is used to compromise access to other IT systems, applications, and data using the vulnerable IoT device as a launch pad? These examples demonstrate the potential liabilities that may occur using IoT devices in the real world. Current liability laws and protection may or may not address IoT devices connected to the public Internet. How can we stay ahead of this legal and regulatory compliance curve? Obviously, to do so is not an easy task. Assessing legal implications of IoT devices and their implementations must address privacy rights of individuals first and then be followed by an understanding of what is acceptable and unacceptable from a liability perspective for businesses involved in IoT device manufacturing or solutions.

E-Commerce and Economic Development Issues

IoT is an e-commerce and economic enabler for less developed countries seeking to connect to the Internet. IoT technology has a significant impact on developing economies given that it can transform countries into e-commerce–ready nations.

Industrial and critical infrastructure solutions that incorporate the IoT may help underdeveloped countries accelerate their global Internet and e-commerce presence, including implementation of IoT critical infrastructure solutions that monitor agriculture, energy, water availability, industrialization, and management of the environment and natural resources. The IoT can help cities, counties, and countries deploy critical infrastructure technologies to accelerate economic development and growth.

Food, water, agriculture, and farming can be supported with IoT devices, sensors, and monitors to help countries build new foundations for agriculture and food processing. Using the IoT to track and monitor progress is a viable solution for governments to deploy as they build critical infrastructure and

provide basic necessities for their people and businesses. Following are examples that the IoT brings to e-commerce and economic development for countries:

- **Infrastructure resources**—Foundational to the deployment of the IoT, a communication infrastructure and broadband Internet network are needed within that country. They are the foundation for IoT device connectivity and communications in a global marketplace.
- **Foundational investments**—Countries seeking to invest in critical infrastructures may be able to leapfrog past other countries that are struggling with regulatory and legal issues regarding accelerating deployments.
- **Technical and industrial development**—New skills are needed to bring new technologies and economic solutions to bear using the Internet and the IoT as key economic drivers. As IoT technology and industry interoperability and standards mature, so will IoT device deployment and user and business adoption.
- **Policy and regulatory definitions**—Countries and emerging economies are positioned to create and implement policies and regulations to help ensure that security and privacy become part of the deployment.

Other considerations emerge when dealing with international e-commerce. When engaging in foreign or international e-commerce, who is responsible for paying taxes and submitting those taxes? Questions like these require answers, especially when the IoT expands beyond countries and international borders.

Critical Infrastructure IoT

Countries implementing new water supply management systems require proper sensor monitoring and tracking to ensure freshwater supplies are maintained and reaching the people who need them. Systems that use software to manage and control physical activities are called industrial control systems (ICSs). The IoT makes ICSs easier to implement due to the easy and inexpensive availability of online sensors and control devices. Agriculture and farming are dependent on water irrigation and can also

benefit from the IoT. Sensors can monitor water supplies as well as water quality, providing near real-time data back to water management systems and personnel. Using this IoT infrastructure to manage an entire region's freshwater supply can support proper population and agricultural growth. Using the IoT to help with water management system planning, including capacity planning, can benefit human and agricultural growth. Once implemented for water management, other similar critical infrastructure services (e.g., wastewater management) can follow a similar implementation path. This IoT foundation can support that country's economic development and e-commerce road map. Agriculture and other natural resources can become part of that country's IoT and international trade e-commerce strategy. Whether that natural resource is water, agriculture, natural resources, or minerals, an IoT foundation can help drive that country's economic development and e-commerce strategy.

CHAPTER SUMMARY

In this chapter, you learned about changes in communication and the impact the Internet has had on people and business. This impact has led us to an IoT, whereby any IP-connected device is able to connect to the Internet. This evolution was created by the Internet and its explosive growth and popularity, and it has transformed our personal and professional lives and the way we conduct business. As more users and their devices connect to the Internet, there are more opportunities for sharing and using information across the IoT universe. These opportunities may include human or personal interaction with the IoT and professional or business interaction with the IoT where businesses are transforming into ASPs to provide new, innovative products and services.

You learned that the IoT is not without business challenges and issues that must be overcome. These new IoT business challenges and issues include all aspects of human interaction with the Internet and IoT-connected devices, including security, privacy, interoperability and standards, legal and regulatory issues, and e-commerce and economic development. Global cooperation and participation in the IoT interoperability and standards area will ensure that all IoT vendors, manufacturers, and ASPs are on a common platform to build and implement IoT devices and solutions for tomorrow's marketplace. Without this global cooperation, the IoT vision as described by the Internet Society will have difficulty getting implemented.

KEY CONCEPTS AND TERMS

Anything as a Service (AaaS)
Application service provider (ASP)
Bring Your Own Device (BYOD)
Business-to-business (B2B)
Business-to-consumer (B2C)
De-identified data
E-commerce
End of Life (EOL)
Internet of Things (IoT)
Interoperability
Metadata
Mobile IP
Privacy
Radio frequency identification (RFID)
Real-time communications
Search engine optimization (SEO)
Social media
Software as a Service (SaaS)
Store-and-forward communications
Unified messaging (UM)

CHAPTER 2 ASSESSMENT

1. The Internet is an open, public network shared by the entire planet. Anyone can connect to the Internet with a computer and a valid Internet connection and browser.
   A. True
   B. False
2. Which of the following are challenges that the IoT industry must overcome?
   A. Security and privacy
   B. Interoperability and standards
   C. Legal and regulatory compliance
   D. E-commerce and economic development
   E. All of the above
3. Which phenomenon helped drive near real-time, high-speed broadband connectivity to the endpoint device?
   A. Internet connectivity
   B. Email
   C. VoIP
   D. Social media sharing
   E. All of the above
4. Which of the following requires an IoT-connected automobile?
   A. Near real-time access to household controls and systems
   B. Ability to track the whereabouts of your children through location-finder GPS applications
   C. Real-time alerts regarding reminders to pay bills on time
   D. Online e-commerce and online shopping with direct delivery
   E. Traffic monitoring sensors that provide real-time updates for traffic conditions
5. Which of the following are impacts of the IoT on our business lives?
   A. E-commerce
   B. Integrated supply chain with front-end sales order entry

C. Companies now offering delivery services for products and services with real-time updates
D. Customer reviews providing consumers with product and service reviews online and with more information about customer satisfaction
E. All of the above

6. Which of the following helps support remote teleworking?
   A. Presence/availability
   B. IM chat
   C. Video conferencing
   D. Collaboration
   E. All of the above
7. What is a security challenge that IoT deployments must overcome?
   A. Congestion of mobile IP traffic
   B. Secure communication with other IoT devices
   C. Liability of an IoT device failing to send an update message
   D. Pricing for software licensing in the IoT device
   E. Privacy data use sharing agreement
8. Unified messaging provides what functionality for users on the go?
   A. Voice messages that are converted to audio files and emailed to the user's inbox for playback while on the road
   B. One-to-many communications
   C. Automatic secure connections, regardless of location
   D. VoIP communications and messaging
   E. Transparent connection between cellular and wireless endpoints
9. Which of the following applications can eliminate the need for in-person training?
   A. Audio conferencing and video conferencing
   B. Social media
   C. IM chat
   D. Presence/availability
   E. All of the above
10. Why do e-commerce systems need the utmost in security controls?
    A. It is a PCI DSS standard.

B. Private customer data is entered into websites.
C. Credit card data is entered into websites.
D. Customer retention requires confidence in secure online purchases.
E. All of the above

11. Which of the following is *not* a challenge that must be overcome by IoT deployments?
    A. Security
    B. Availability
    C. Legal and regulatory
    D. E-commerce and economic development
    E. Privacy
12. Typically, data must be _____ to be shared or used for research purposes.
    A. Encrypted
    B. Hashed
    C. De-identified
    D. Masked out
    E. In cleartext

CHAPTER 3
Risks, Threats, and Vulnerabilities

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NOTHING IN LIFE IS CERTAIN and that applies to organizations. Uncertainty means that the possibility exists that something might occur that changes an expected output. Another term for uncertainty is *risk*. All organizations encounter risk, and implementing technology tends to increase that risk. To best manage risk so that it doesn't become overwhelming, you first need to learn about the risks, threats, and vulnerabilities to organizations, their information technology (IT) infrastructures, and their sensitive data. Risk management is a formal approach to how organizations address risk. Because organizations connect to the Internet and remotely access their IT infrastructures, malicious attackers can try to steal the data being transmitted. If your device and sensitive information are connected to the Internet, the potential for loss or damage exists.

Unlike in your everyday life, in cyberspace there is no real law of the land. Criminal acts that lead to destruction and theft occur regularly. These acts are called threats. Risks and threats affect businesses, individuals, and governments. Hackers attempt to find vulnerabilities in your IT infrastructure or software installed on your IT assets. A vulnerability is a weakness in the design of a system, application, software, or asset. Criminals who attempt to compromise your IT infrastructure often go unidentified and unpunished, as was the case with the Marriott hack that occurred in 2020. Hackers were able to compromise the logon credentials of two Marriott employees who had access to customer information. This hack resulted in 5.2 million hotel guests who were part of the Marriott loyalty program being exposed to potential identity theft and fraud. Previously, in 2018, Marriott's Starwood brands had suffered a major data breach that affected up to 500 million hotel guests and their private data.

Cyberattacks are threats that result in billions of dollars in damages each year. Fortunately, many companies and individuals like you are working hard to protect IT and information assets from attacks. In this chapter, you will

learn how to identify risks, threats, and vulnerabilities and how to protect your organization from them to keep IT assets and sensitive data safe.

Chapter 3 Topics

This chapter covers the following topics and concepts:

- How risk management and information systems security align
- What risk terminology is
- What the elements of risk are
- What the purpose of risk management is
- What the two approaches for risk assessments are
- What a risk management plan is
- What IT and network infrastructure are
- Who the perpetrators are
- What a threat is
- What the different types of threats are
- What a vulnerability is
- How attackers use vulnerabilities to exploit IT assets
- What common attack vectors are
- Why countermeasures are important

Chapter 3 Goals

When you complete this chapter, you will be able to:

- Understand the principles of organizational risk management
- Distinguish between risks, threats, and vulnerabilities
- Identify common risks to an IT infrastructure
- List physical security controls
- Identify attack perpetrators
- Relate threats to an IT infrastructure

- Recognize how vulnerabilities are used to exploit an IT infrastructure

Risk Management and Information Security

Risk management is a central focus of information security. Every action an organization takes—or fails to take—involves some degree of risk. Attention to risk management can mean the difference between a successful business or a failing business. That does not mean every risk is eliminated. Instead, organizations should seek a balance between the utility and cost of various risk management options. Different organizations have different risk tolerances. For example, an established hospital seeks to limit risk to the highest degree possible, whereas a new startup business with only a handful of employees may be more willing to take on risks that may result in attractive financial returns.

As a security professional, you will work with others to identify risks and to apply risk management solutions to ensure that critical business functions can continue to operate in the face of obstacles or interruptions. You must remember two key risk management principles:

- Do not spend more to protect an asset than it is worth. Determining the worth of an asset versus the potential loss from a risk can be more difficult than it first appears. You must understand the true impact of each risk and that the impact may extend beyond obvious recovery costs. Security breaches, such as a successful attack, can degrade customer confidence, resulting not only in immediate costs but also in losing customers to a competitor. The true cost can be far higher than immediate cleanup costs.
- Every countermeasure requires resources to implement and therefore should be aligned with a specific risk. A countermeasure that doesn't mitigate a specific identified risk is a solution seeking a problem; it is difficult to justify the cost.

Information security personnel play an important role in supporting an organization's strategic goals. Activities that include risk, response, and recovery align with the most basic goal: to stay in business. You must help identify risks to understand steps to take if any one of those risks is realized.

Some realized risks are serious and could put your company out of business. For example, a data breach could hurt your company's reputation, result in lost sales, and may even end up costing a lot of money as a result of fines or settlements. The first step in planning to manage information security risk is to conduct a *business impact analysis* (BIA), which identifies your organization's most important business functions and how risks could impact each one. After creating a BIA, you'll help create and/or maintain a plan that makes sure your company continues to operate in the face of disruption caused by a realized risk. This type of plan is a *business continuity plan* (BCP). It is an important concept you will learn about in this chapter along with learning about the BIA. Disruptions do happen, so you must expect they will happen to your organization. Planning for disruption is part of your role as a security professional. Organizations must also develop and maintain a *disaster recovery plan* (DRP) to help address situations that damage or destroy necessary parts of the supporting IT infrastructure. As a security professional, your goal is to make sure your systems and services quickly become available to users after an outage and that you recover any lost or damaged data. However, you also play a role in making sure you handle the recovery process correctly.

NOTE

You should become familiar with the National Institute of Standards and Technology (NIST) SP 800 series of security standards practices. You can find the series at *http://csrc.nist.gov/publications/PubsSPs.html*. This basic information is the foundation for your understanding of information security. Advanced security professionals will use some of the more detailed items.

Risk Terminology

Managing risk is the process of identifying risks and deciding what to do about them. The first step in managing risk is identifying and assessing risk,

all in the context of achieving an organization's strategic goals. Risk that can affect an organization's ability to meet its goals is important, and risk that has no effect on reaching strategic goals is of less importance. But what is risk? And how are risks assessed? Before you learn about managing risks, it is important to understand a few terms. The following terms describe risk assessment types, or ways to define and discuss risks:

- **Risk**—Risk is the likelihood that something bad will happen. Most risks lead to possible damage or negative results that could impact an organization. Not all risks are inherently bad; some risks can lead to positive results. The extent of damage (or even positive effect) from a threat determines the level of risk.
- **Threat**—A threat is something bad that might happen to an organization. A threat could be a tornado hitting a data center or an attacker exfiltrating and leaking (perhaps for profit) sensitive data.
- **Vulnerability**—A vulnerability is any exposure that could allow a threat to be realized. Some vulnerabilities are weaknesses, such as a software bug, and some are just side effects of other actions, such as when employees use their personally owned smartphones to access corporate email or the corporate network.
- **Impact**—**Impact** refers to the amount of risk or harm caused by a threat or vulnerability that is exploited by a perpetrator. For example, if malware or malicious software infects a system, the impact could affect all the data on the system, as in the case of a cryptolocker, which encrypts production data.

NOTE

Many people have never thought of risk as a positive thing. However, uncertainty can result in events that have negative *or* positive effects. For example, suppose your organization plans to deploy new software to your users and partners, based on projected availability from your software vendor. Your risk management plan should address the responses to both an early and a late software delivery. If you receive the software early,

you can either perform more exhaustive testing or begin deployment early. If your software vendor is late in delivering the software, you may miss your projected deployment date. You should have plans in place to address both the positive and negative effects of a delivery date of software that does not match the schedule for its implementation.

When a threat is realized, an organization experiences either an event or an incident. An **event** is a measurable occurrence that has an impact on the business, either having little effect or perhaps escalating into an incident. An **incident** is any event that either violates or threatens to violate a company's security policy and that justifies a countermeasure; for example, employee warehouse theft is an incident.

You will learn more about controls, countermeasures, and safeguards throughout this chapter. Many people use these terms interchangeably, although there are subtle differences. All three mitigate risk by reducing either a vulnerability or the impact of a threat. Controls include both safeguards and countermeasures, or, in other words, they are actions taken to limit or constrain behavior. **Safeguards** address gaps or weaknesses in the controls that could otherwise lead to a realized threat, and **countermeasures** mitigate or address a specific threat. A fire sprinkler system is an example of a countermeasure.

Elements of Risk

Assets, vulnerabilities, and threats are elements of risk, being component parts of risk rather than a formula. Existing vulnerabilities, as well as new threats, which emerge daily, should be identified and addressed by employing proactive procedures. As these factors change over time, risk can also change, hence the reason organizations should periodically perform risk assessments to identify new or changed risks over time.

Do not assume that all threats come from the outside. *CSO* online magazine, the Community Emergency Response Team (CERT) program, PricewaterhouseCoopers, Deloitte, Microsoft, and the U.S. Secret Service annually release the *Cybersecurity Watch Survey*. This report explains that insider attacks make up a little more than a quarter (28 percent) of all

reported attacks. Other sources, including the FBI and Verizon's annual *Data Breach Investigations Report*, state that insider attacks, which are becoming more sophisticated all the time, make up just over 20 percent of overall attacks. However, their impact is proportionately worse than attacks by outsiders.

NOTE

The *Cybersecurity Watch Survey* can be found online at *www.cert.org/insider-threat/research/cybersecurity-watch-survey.cfm*.
The CERT program is part of the Software Engineering Institute, based at Carnegie Mellon University. It has a comprehensive online resource, the CERT Insider Threat Center, at *www.cert.org/insider-threat/cert-insider-threat-center.cfm*. Another great resource, the latest Verizon *Data Breach Investigations Report*, can be found at *https://enterprise.verizon.com/resources/reports/dbir/*.
New threats appear constantly, and one of the resources for receiving updates is the United States Computer Emergency Readiness Team (US-CERT), which regularly releases information on new threats via email. You can subscribe to its Technical Cyber Security Alerts, Cyber Security Bulletins, or Cyber Security Alerts through this website: *https://us-cert.cisa.gov/ncas/alerts*. Once you sign up, you will receive regular email alerts. You can also subscribe to its newsfeeds or follow it on Twitter.

Purpose of Risk Management

The purpose of risk management is to identify possible problems before something bad happens. Early identification is important because it provides the opportunity to manage those risks instead of just reacting to them. It is important to identify risks:

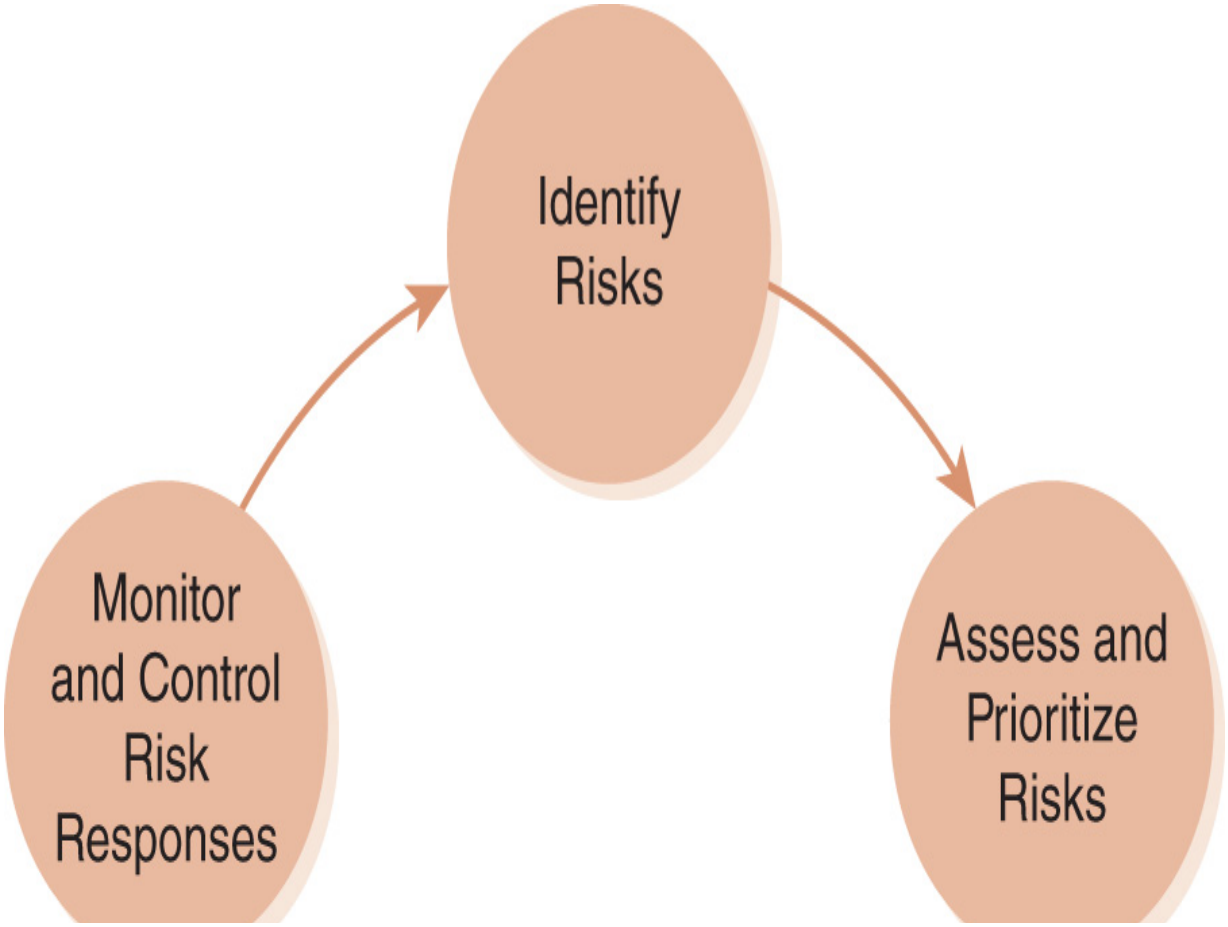
- Before they lead to an incident

- In time to enable a plan and begin risk-handling activities (controls and countermeasures)
- On a continuous basis across the life of the product, system, or project

Risk can never be reduced to zero; therefore, contingency planning focuses on building the plans to anticipate and respond to risk without interrupting the most critical business functionality. After identifying the risk culture of an organization, you need to evaluate risks and then handle the ones that could have a material effect on the organization first. The costs of risk-handling methods must be justifiable. In many cases, small risk reductions may have prohibitively high costs. Part of your job is to identify the tolerable risk level and apply controls to reduce risks to that level. You must focus some risk management efforts on identifying new risks so you can manage them before a negative event occurs. Part of this process will include continually reevaluating risks to make sure the right countermeasures have been implemented to ensure that the organization can continue operations even when incidents occur.

The Risk Management Process

FIGURE 3-1 shows the risk management process, which is one that never really ends. It is important to periodically move through the complete cycle to be ready for current threats, especially any new threats that may have emerged since the last pass through the cycle. The process defines how the steps of managing risk for an organization will be carried out. For example, the approach could state that risk analysis will be conducted at specified intervals, using tools that can include the documents that define, categorize, and rank risks. This approach is consistent with the Project Management Institute's (PMI's) Project Management Body of Knowledge (PMBOK). The PMI approach is not the only way to do things; however, it does provide a prescriptive approach to project management in general, including risk management.



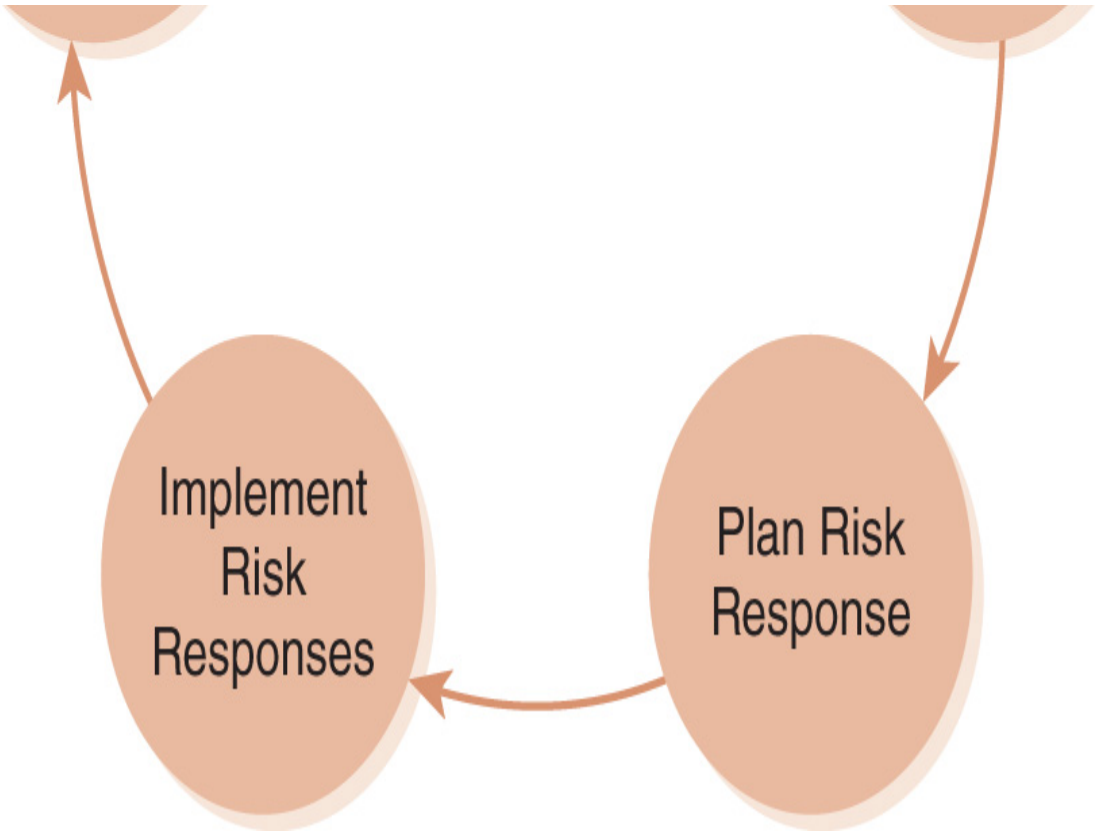


FIGURE 3-1 Risk management process.

Following are the steps in the risk management process:

- **Identify risks**—The first step to managing overall risk is to identify the individual risks. What could go wrong? What could interrupt operational readiness and threaten the availability of functions and services the organization provides? Answers to that question include fire, flood, earthquake, lightning strike, loss of electricity or other utility, communication interruption, labor strike, pandemic, or transportation unavailability. You must develop scenarios for each risk to assess the threats.
- **Assess and prioritize risks**—Some risks pose a greater possibility of loss or interruption than others. Furthermore, not all risks apply to all businesses in all locations. For example, businesses in North Dakota or South Dakota do not need to worry about hurricanes. Of the risks that are possible, impact will be more or less severe depending on the scenario and location. Therefore, assessing risk is about determining

which risks are the most serious ones for a specific location and environment.

- **Plan risk response**—Starting with the highest-priority risks, explore potential responses to each one. With direction from the organization's upper management, determine the responses to each risk that provide the best value.

NOTE

It is important to avoid spending time and money on "movie plot" risks. Scriptwriters can create impossible scenarios and make them look possible or even likely. Spending money to protect against these false threats is almost always a waste. Instead, focus on realistic risks that have a high likelihood of occurrence.

- **Implement risk responses**—Take action to implement the chosen responses to each risk from the previous step.
- **Monitor and control risk responses**—Monitor and measure each risk response to ensure that it is performing as expected. This step can include passive monitoring and logging, as well as active testing, to see how a control behaves.

Identify Risks

The first step in the risk management process is to identify risks. Organizations use several methods to identify risks, each one using a different approach to solve the same problem—identifying as many risks as possible. In each method, the basic strategy is to use input from multiple sources to build a comprehensive list of risks. Some of the more popular risk identification methods follow:

- **Brainstorming**—This technique involves getting unstructured input from members of the organization in a group meeting. The facilitator

should encourage all members to offer suggestions without fear of criticism or ridicule.

- **Surveys**—Organizations that use surveys send lists of prepared questions to a variety of people from different areas of the organization for input. One such survey technique is the Delphi method, in which responses are anonymized to foster more open dialogue, shuffled, and sent back to participants for comment.
- **Interviews**—Interviews, held in either group settings or one on one, can be an effective approach to gather details on risks from the interviewee's perspective.
- **Working groups**—This technique focuses on soliciting feedback from a group of individuals selected from a specific work area to help identify risks in that area.
- **Checklists**—Many organizations develop checklists of risks for either their own use or general distribution. Checklists developed for similar organizations or purposes can be helpful to ensure that the breadth of risks are covered.
- **Historical information**—Unless an organization is brand new, it will have some historical information at its disposal. This information may be a previously encountered risk identification process or documentation of things that went wrong in the past. Either way, historical information can be valuable to identify current risks.

To identify risks, most organizations use several methods that work best for the organizational culture, with the most important factor being to engage as many people as possible from different functional areas. The best outcome from this process is to identify far more reasonable risks than the organization can handle. Although that sounds like asking for trouble, it is much better than completely missing important risks. Try using as many risk identification methods as possible to find the best mix of methods for the organization.

The result of the risk identification process is a list of identified risks, which the PMI calls the risk register (see **FIGURE 3-2** for an example**)**. The risk register can contain several types of information but should contain at least the following:

Risk Management											
ID	Brief Risk Description	Risk Category	Response Action/ Strategy	Response Action/ Strategy Description	Responsible Individual	Monitoring and updating			Post-treatment risk rating		
						Trigger Event(s)	Status	Risk Resolution Date	Impact	Likelihood	Risk Rating
Auto	*Auto*	*Auto*	*Drop Down*	*Manual*	*Manual*	*Manual*	*Drop Down*	*Manual (MM/DD/YY)*	*Drop Down*	*Drop Down*	*Auto*

FIGURE 3-2 Sample risk register.

- A description of the risk
- The expected impact if the associated event occurs
- The probability of the event's occurring
- Steps to mitigate the risk
- Steps to take should the event occur

- Rank of the risk

Assess and Prioritize Risks

A good risk assessment explains the company's risk environment to managers in terms they clearly understand and what risks could stop a company from carrying out normal operations. Sometimes, IT professionals are biased about protecting their IT structure and minimize the fact that their systems are there to support the organization's primary objectives. Therefore, during the risk assessment process, it is important to remain focused on "What does this risk mean to the company?" and "What is the impact of this risk to the company?" rather than "What does this mean for my systems and IT infrastructure?" Risk must be assessed objectively, especially outside of the IT perspective.

NOTE

Regardless of how sophisticated the risk management plans are, incidents will occur. Risk management (i.e., identification, assessment, and response) coupled with continuity and disaster planning (covered later in this chapter) often means the difference between a company's surviving or failing after an outage.

Although many options are available to respond to risks, a key reason for performing a risk assessment is to provide the data necessary to make a risk management business decision, which depends on such things as impact, likelihood of occurrence, or time and cost to remediate.

You can approach risk assessment in two ways:

- **Quantitative risk assessment** is an approach in which the cost or value of the identified risk and its financial impact are examined. By quantifying risks, a financial business decision can be made in alignment with a risk transfer strategy (e.g., buying more insurance coverage). This type of risk assessment is easier to automate and more

objective than a qualitative analysis in that it attempts to describe risk in financial terms and put a dollar value on each risk. One drawback to this approach, though, is that many risks have difficult-to-measure values, such as brand reputation and the availability of countermeasures or security controls, for which exact numbers can be difficult to determine, especially the cost of the impact of future events.

- **Qualitative risk assessment** is an approach in which the risk impact is examined by assigning a rating for each identified risk (e.g., critical, major, or minor or high, medium, or low). When performing a qualitative risk assessment, the assessor must examine both the risk impact and the likelihood of occurrence. Impact is the degree of effect a realized threat would pose and is often expressed from low (insignificant) to high (catastrophic). Qualitative risk assessments can be fairly subjective, but they do help determine the most critical risks. This type of assessment requires diverse input from people who work in different departments, which allows the business units and technical experts to understand the ripple effects of an event on other departments or operations and encourages the use of relative terms, for example, asking which risks are worse than others.

Quantitative assessments are numerically driven and put a dollar figure or cost on the risk, whereas qualitative assessments define risks based on a scenario or soft data by assigning the risk a severity and probability of occurrence. **FIGURE 3-3** compares quantitative and qualitative risk assessments. Neither approach is perfect, but most people find qualitative risk assessments to be simpler to conduct.

Quantitative	Numerically based (hard) data	Financial data (objective)
Qualitative	Scenario-based (soft) data	Scenario-oriented (subjective)

FIGURE 3-3 Quantitative versus qualitative risk assessments.

In many situations, it is helpful to combine the two methodologies. Qualitative risk analysis provides a better understanding of the overall impact a disruption will have as the effects ripple through an organization and often leads to better communication between departments in terms of how they must work together to reduce damage. However, compared to a quantitative risk analysis, it lacks some of the solid financial data, which is often necessary to justify the cost of countermeasures. Therefore, you need to consider both techniques.

Quantitative Risk Assessment

To calculate the quantified risk for a specific asset, the value of the asset and the probability that a loss will be encountered must be assessed. This is the event's **loss expectancy**. Calculating it is a multistep process:

1. **Calculate the asset value (AV)**—An **asset** is anything of value to an organization. Assets can be tangible (e.g., buildings) or intangible (e.g., reputation). The first step in risk assessment is to determine all the organization's assets and their value, that is, the importance of each asset to the organization's ability to fulfill its strategic goals. Asset value should consider the replacement value of equipment or systems and include factors such as lost productivity and loss of reputation or customer confidence.

2. **Calculate the exposure factor (EF)**—The EF represents the percentage of the asset value that would be lost if an incident were to occur. For example, not every car accident is a total loss; therefore, insurance companies have actuaries who calculate the likely percentage loss for every claim. They know the cost of repairs for every make and model and can predict the EF per claim. Their prediction will not be right for any single claim (except by chance), but it will be quite accurate when grouped by the hundreds or thousands.
3. **Calculate the single loss expectancy (SLE)**—The value of a single loss can be calculated using the two preceding factors. If actuaries calculate that the EF of a late-model SUV is 20 percent, then every time they receive a claim, all they need to do is look up the AV and multiply by the EF; thus, they will have a very good prediction of the payout. The SLE allows actuaries to calculate insurance premiums accurately and reduce the risk of the insurance company's losing money.
4. **Determine how often a loss is likely to occur every year**—This calculation is called the annualized rate of occurrence (ARO), also known as the risk **likelihood**. Some AROs are greater than 1, such as a snowstorm in Buffalo or Berlin, an occurrence that will happen many times per year. Other AROs are likely to happen far less often, for example, a warehouse fire, which might happen once every 20 years. Estimating how often an incident will happen is often difficult because historical data does not always predict the future. Moreover, internal and external factors can affect that assessment. For example, an incident stemming from an internal threat is far more likely during times of employee unrest or contract negotiations than at other times.
5. **Determine annualized loss expectancy (ALE)**—The ALE is the SLE (the loss when an incident happens) times the ARO. The ALE helps an organization identify the overall impact of a risk. For infrequent events, the ALE will be much less than the SLE. On the one hand, if an event is expected to occur only once every 10 years, the ARO is 0.10, or 10 percent. If the SLE is $1,000, the ALE is only $100 ($1,000 × 0.10). On the other hand, if the ARO is 20, indicating that the event is likely to occur 20 times every year, the ALE is $20,000 ($1,000 × 20).

TABLE 3-1 shows the calculations you can use to determine quantified risk. The purpose of calculating quantified risk is to find the highest amount that should be spent on a countermeasure, which should be less than the ALE.

TABLE 3-1 Determining quantified risk.

CALCULATION	FORMULA
Single loss expectancy (SLE)	AV × EF = SLE
Annualized rate of occurrence (ARO)	ARO = Number of incidents per year
Annualized loss expectancy (ALE)	SLE × ARO = ALE

Consider this example. About 100 users in an organization use laptop computers. The value of each computer is $1,500, which includes the cost of the computer, the software, and the data. In the past two years, the organization has lost an average of six computers per year. With this information, you can calculate the SLE, the ARO, and the ALE.

- The SLE is $1,500.
- The ARO is 6.
- The ALE is $9,000 ($1,500 × 6).

As a countermeasure to protect against the loss of these computers, the suggestion has been made to purchase hardware locks so unattended computers can be locked to furniture, the way bicycle riders lock their bikes to a bike rack. If the locks are purchased in bulk, they cost $10 each, and their use is estimated to reduce yearly losses from six to only one. Is this a cost-effective countermeasure?

NOTE

The opinions of many experts are often needed to determine where to place risk on both scales, and you must work to get a consensus if the

experts disagree. This kind of analysis can account for intangible factors, such as reputation or public interest.

- Cost of countermeasure is $1,000 ($10 × 100 computers).
- New ARO is 1.
- New ALE is $1,500 ($1,500 × 1).

Clearly, this is a cost-effective control; instead of losing $9,000 a year, the organization spends $1,000 and loses only $1,500. Contrarily, if the cost of the countermeasure were $20,000, it would not make sense because $20,000 would be spent to potentially save $9,000, which would cost the organization an additional $11,000.

Qualitative Risk Assessment

You can judge every risk on two scales:

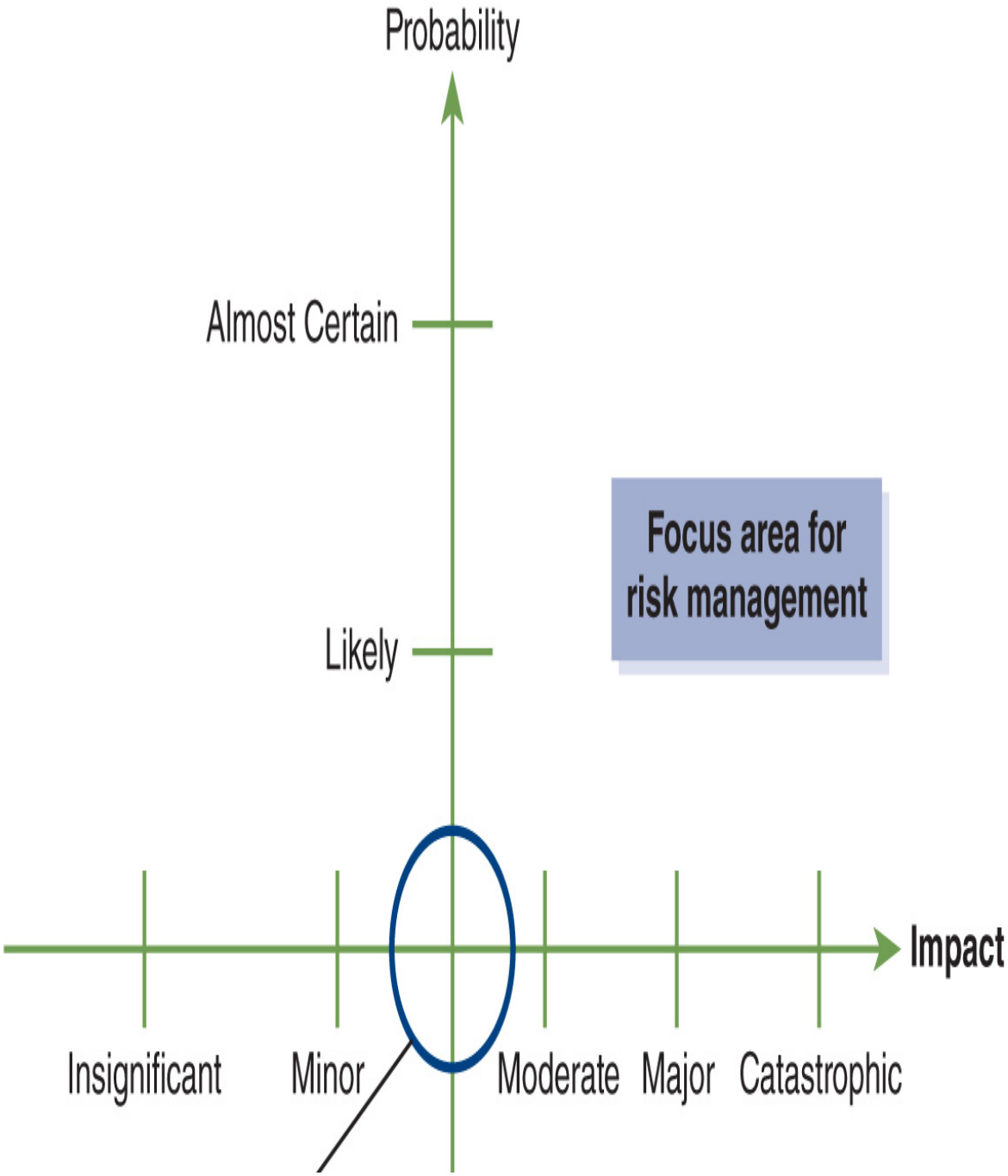
- **Probability or likelihood**—Some things, such as the malfunction of a badge reader on the employee entrance, will seldom happen, whereas other things, such as employees calling in sick, will almost certainly happen.
- **Impact**—Some things, such as a workstation that fails to boot up, will have a minor impact on productivity, whereas other things, such as a production system breaking down, will have a major impact.

NOTE

Previously, we stated that organizations should track and report their risk elements in a risk register. Using a risk register will help organize the results of qualitative risk assessments by listing all the risks, prioritizing them based on risk impact or risk exposure, and indicating the likelihood of each risk occurring. Use of a risk register tool or spreadsheet can assist organizations with tracking and reporting so that the organization can make important business decisions pertaining to risk transfer,

avoidance, mitigation, or acceptance for identified risks. This exercise should be performed before the annual renewal of any business liability insurance or purchasing or renewing cybersecurity insurance policies.

You should evaluate events with respect to both scales and then place them on the chart shown in **FIGURE 3-4**.



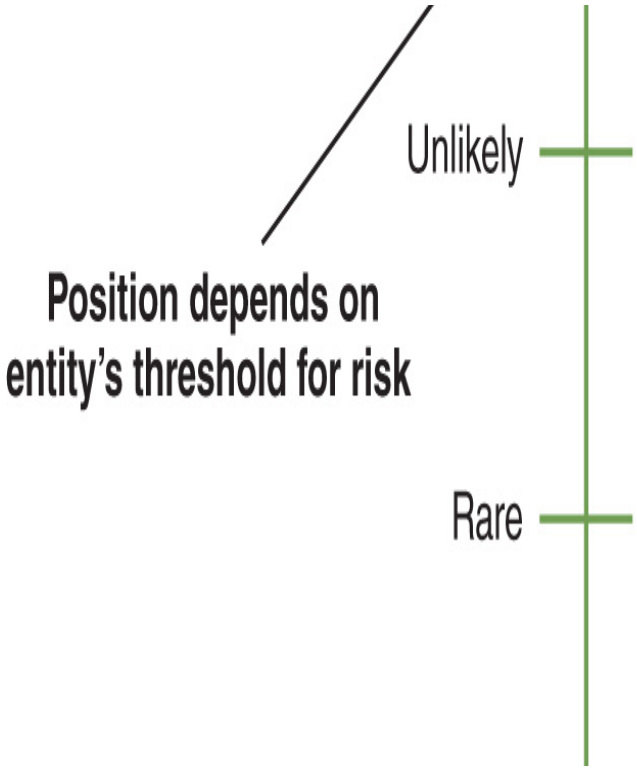


FIGURE 3-4 Qualitative risk assessment.

Notice the quadrant labeled "Focus area for risk management." These risks have both a high probability and a high impact. Any risk that appears in this quadrant should be evaluated first and countermeasures applied to reduce the probability of the risk or its impact. Do not confine risk management activities solely to the upper-right quadrant; however, keep in mind that this quadrant is where all initial risk response efforts should be focused. Risk mitigation, transference, acceptance, or avoidance (covered in the next section) reduces the risks in the upper-right quadrant. As a reminder, the goal is not to eliminate risk but instead to reduce risk to an acceptable level.

Plan a Risk Response Strategy

The next two steps in the risk management process deal with developing a plan to handle risks and then to implement that plan. Understanding the most common responses to each negative risk is important when developing risk management strategies:

- **Reduce (reduction/mitigation)**—This approach uses various administrative, technical, or physical controls to mitigate or reduce identified risks. For example, adding antivirus software reduces the risk of computer infection.
- **Transfer (transference/assignment)**—This approach allows the organization to transfer the risk to another entity, such as with insurance. In this way, an organization "sells" the risk to an insurance company in return for a premium. Risks can also be transferred to insulate an organization from excessive liability. A hotel, for example, engages a separate car-parking corporation to manage its parking lot and in effect transfers the responsibility for losses to the car-parking corporation, making an incident in the parking lot less likely to put the hotel in jeopardy of a lawsuit.
- **Accept (acceptance)**—This approach allows an organization to accept risk and is dependent on the risk appetite of senior management. Even though the organization knows the risk exists, it has decided that the cost of reducing the risk is greater than the loss would be. Self-insuring or using a deductible may be part of this approach. For example, a physician buys malpractice insurance and accepts the residual risk of loss equal to the deductible. The physician might decide to pay an even higher premium to reduce the deductible but could also decide that the higher premium would not be worth the cost because of expectations that claims would rarely be made.
- **Avoid (avoidance)**—Risk avoidance is just that—deciding not to take a risk. A company can discontinue or decide not to enter a line of business if the risk level is too high. With avoidance, management decides that the potential loss to the company exceeds the potential value gained by continuing the risky activity. For example, a company may decide not to open a branch in a country mired in political turmoil.

For positive risks, you can exploit, share, enhance, or accept each risk:

- **Exploit (exploitation)**—When you **exploit** a positive risk, you take advantage of an opportunity that arises when you respond to that risk. For example, suppose an organization developed training materials for

use to help address a specific risk. You might exploit the risk by packaging and marketing those training materials to other organizations.

- **Share (sharing)**—When you share a positive risk, you use a third party to help capture the opportunity associated with that risk. For example, banding with another organization to purchase a group of workstation licenses enables both organizations to realize a substantial discount due to the size of the combined order (in this case, the risk is that the license cost may change).
- **Enhance (enhancement)**—When you enhance a positive risk, you increase the probability of the positive impact of the event associated with the risk. For example, suppose a company has a contract to deliver software that includes a $20,000 bonus for early delivery. To enhance the positive risk (a delivery date that precedes that of the contract), a subcontractor is offered a $5,000 bonus for finishing ahead of the deadline.
- **Accept (acceptance)**—When you accept a positive risk, you take no steps to address it because the potential effects of the risk are positive and add value. For example, suppose an organization has purchased a new automated backup and configuration utility that can help deploy new workstations in half the allotted time, but, because the utility is new, it may take some time to learn, meaning it may *not* help the organization save any time deploying new workstations. It has been determined that, at worst, learning the new utility and using it to manage deployments would take the same amount of time as deploying the workstations manually. However, to realize the positive risk, the deployments would be finished sooner than planned.

Acceptable Range of Risk/Residual Risk

The acceptable range of risk determines how activities and countermeasures are defined. The upper boundary is the risk impact where the cost would be too great for the organization to bear. The lower boundary shows the increased cost of the countermeasures to handle the residual risk. **FIGURE 3-5** illustrates that the goal of risk management is to stay inside the acceptable range.

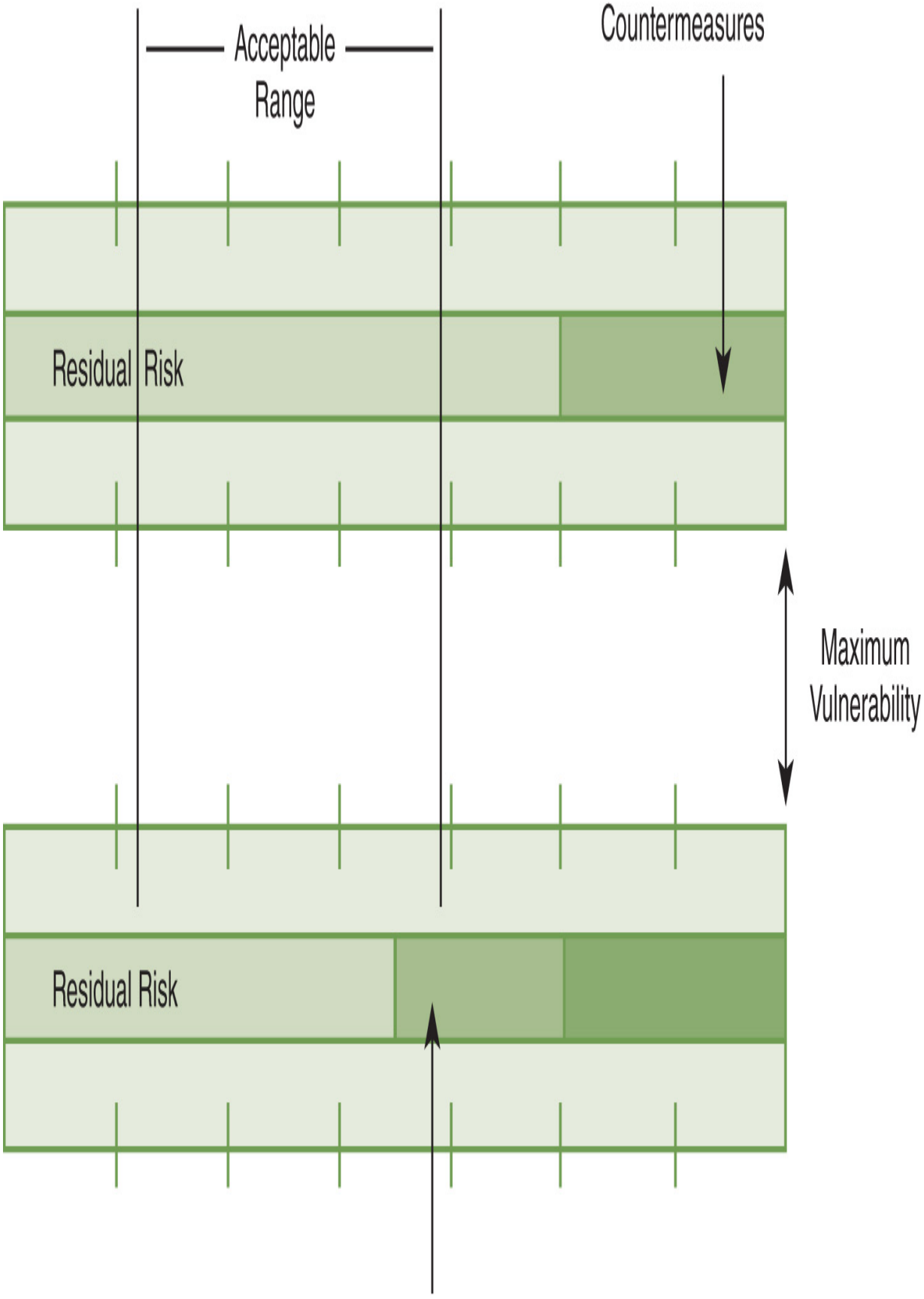

Acceptable
Range
Countermeasures
Residual Risk
Maximum
Vulnerability
Residual Risk

FIGURE 3-5 Acceptable range of risk.

The top graph represents the total exposure to an organization for a specific risk. The in-place countermeasures are not adequate to reduce the risk from the maximum acceptable residual risk level into the acceptable range. The lower graph shows the proposed countermeasures that would reduce the maximum residual risk level to the acceptable range.

Total risk is the combined risk to all business assets. **Residual risk** is the risk that remains after countermeasures and controls have been deployed:

$$\text{Risk} - \text{Mitigating controls} = \text{Residual risk}$$

Applying countermeasures and controls reduces but does not eliminate risk. Consider the example of car insurance. When you purchase a brand-new car, it loses value as soon as you drive it off the dealer's lot because it is now used. If an accident damages the car to the extent that it is a total loss, insurance may not reimburse you for the original price you paid for the car. The difference between what the insurance company pays and what you actually paid for the car is the residual risk. Other examples include the deductible on insurance or the remaining (but decreased) chance of fire after implementation of alarms, sprinkler systems, and training sessions. The difference between total risk and residual risk is shown in **FIGURE 3-6**.

NOTE

Usually, risk cannot be entirely eliminated. An organization must select a level of risk that it is willing to accept, which is known as the acceptable range.

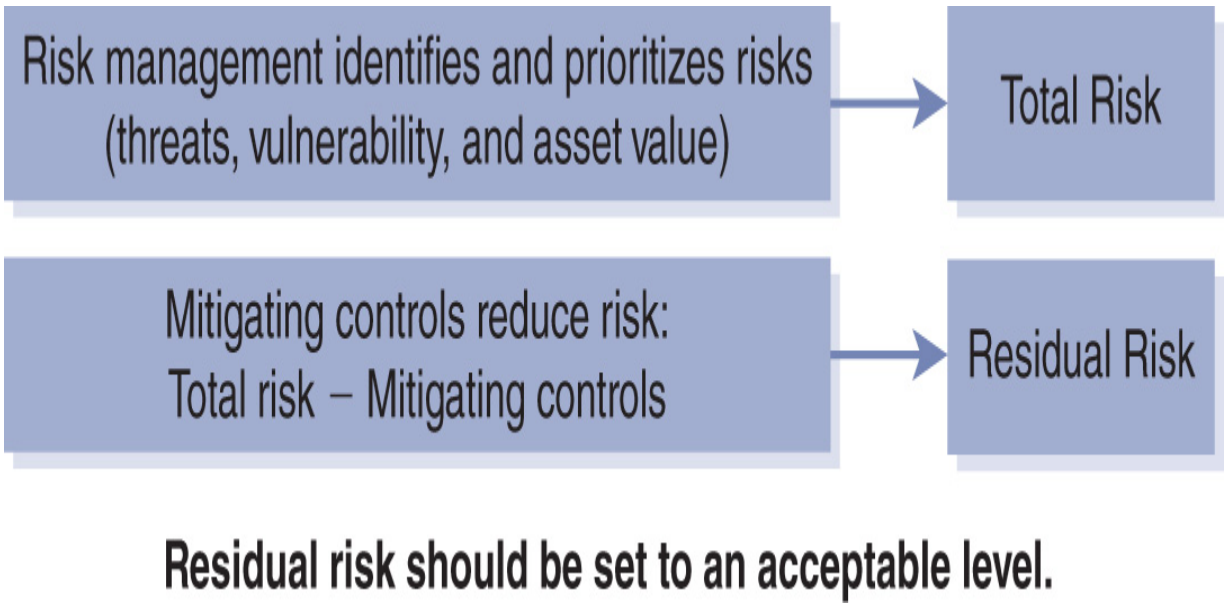

Risk management identifies and prioritizes risks (threats, vulnerability, and asset value)
Total Risk
Mitigating controls reduce risk: Total risk – Mitigating controls
Residual Risk
Residual risk should be set to an acceptable level.

FIGURE 3-6 Total risk and residual risk.

An organization should be prepared to accept the cost of residual risk. It may choose not to eliminate risk entirely because doing so is impossible or just too expensive. If the cost of residual risk is too great, though, the organization must either eliminate the risky behavior or use a different countermeasure.

NOTE

NIST suggests three control categories in NIST SP 800-53a:

- **Management controls**—These controls are used to manage the entire risk process. For example, reviewing security controls and developing and maintaining the overall security plan are management controls.
- **Operational controls**—Operational personnel may implement and manage these controls, such as physical security and incident response.
- **Technical controls**—These controls comprise computer programs, such as identification systems, or the output of computer programs,

such as log files for audit trails.

Implement the Risk Response Plan

Security controls are the safeguards or countermeasures that an organization uses to avoid, counteract, or minimize loss or system unavailability. As defined by the Institute of Internal Auditors:

> The control environment sets the tone of an organization, influencing the control consciousness of its people. It is the foundation for all other components of internal control, providing discipline and structure. Control environment factors include the integrity, ethical values, and competence of the entity's people; management's philosophy and operating style; and the way management assigns authority and organizes and develops its people.

Some controls manage the activity phase of security, or the things people do, and are known as **administrative controls**. Administrative controls develop and ensure compliance with policy and procedures. They tend to be things that employees might do, are supposed to do, or are not supposed to do. A control carried out or managed by a computer system is a **technical control**.

Activity phase controls can be either administrative or technical. They correspond to the life cycle of a security program as follows:

- **Detective controls**—These controls identify that a threat has landed in a system. An intrusion detection system (IDS) is an example of a **detective control**. An IDS can detect attacks on systems, such as port scans that try to gain information about a system. The IDS then logs the activity.
- **Preventive controls**—These controls stop threats from coming into contact with a vulnerability. An example of a **preventive control** is an intrusion prevention system (IPS). An IPS is an IDS that is configured to actively block an attack. Instead of simply logging the activity, an IPS can change the configuration so that the malicious activity is blocked.

- **Corrective controls**—These controls reduce the effects of a threat. When you reload an operating system after it is infected with malware, you are using a **corrective control**. Forensics and incident response are other examples of corrective controls.
- **Deterrent controls**—These controls deter an action that could result in a violation. A fine line exists between **deterrent controls** and preventive controls. Deterrent controls merely attempt to suggest that a subject not take a specific action, whereas preventive controls do not allow the action to occur. Deterrent controls are valuable when a knowledgeable user needs the ability to perform an action that involves risk. A deterrent control would allow the action after a warning, whereas a preventive control would not allow the action at all. In short, the decision to choose between a preventive and a deterrent control is often a balance between utility and security.
- **Compensating controls**—These controls are implemented to address a threat in place that does not have a straightforward risk-mitigating solution.

Selecting Safeguards and Countermeasures

As introduced earlier in the chapter, the terms *control*, *safeguard*, and *countermeasure* are not interchangeable. A *control* limits or constrains behavior, whereas *safeguards* and *countermeasures* are controls that exercise restraint on or management of an activity. For example, a safe for storage of valuables is a control, a human guard who watches the safe is a safeguard, and insurance against loss of the valuables if they are stolen is a countermeasure. The countermeasure counters, or addresses, the loss from a specific incident.

The number of possible countermeasures is unlimited. A countermeasure must have a clearly defined purpose: It must address a risk and reduce a vulnerability because a countermeasure without an exposure (risk) is a solution seeking a problem. Following are examples of specific purposes of countermeasures:

- Fix known exploitable software flaws
- Develop and enforce operational procedures and access controls (data and system)

- Provide encryption capability
- Improve physical security
- Disconnect unreliable networks

All personnel need to be aware of their security responsibilities. Security is a full-time job for some people, whereas other people have only infrequent responsibilities, such as locking the door on the way out. Following are examples of specific security responsibilities that you may hold:

- Delete redundant/guest accounts
- Train system administrators (specific training)
- Train everybody (general training)
- Install virus-scanning software
- Install IDS/IPS and network-scanning tools

Protecting Physical Security

One special class of risks to an organization is physical security, which is a requirement for a solid overall security plan but oftentimes dismissed by IT security professionals in favor of focusing on technical security controls. Always assess the best security controls as part of a risk management program. All critical IT assets must be physically secured at all times, and many controls are available that can be implemented to ensure that security. Here is a partial list of the most common environmental and physical controls that are needed to maintain a secure IT environment:

- **Heating, ventilating, and air conditioning (HVAC)**—These systems provide proper airflow, temperature, and humidity for IT components to operate and must be designed well and operate efficiently to support the IT infrastructure. The design for data centers should include hot aisles (for IT component heat venting) and cold aisles (for drawing cold air into IT components). Moreover, they must also be designed to provide necessary services at all times while using as little energy as possible, to keep costs down. All environmental

controls must be monitored for proper operation to ensure that the data center maintains the required temperature and humidity.

- **Fire suppression**—This consideration includes devices and systems designed to extinguish fires of different types to minimize damage and stop fires from spreading.
- **EMI shielding**—This consideration includes physical barriers placed around wiring or into building materials to limit electromagnetic interference (EMI) outside protected areas.
- **Lighting**—Lights are placed to ensure all areas are well lit, with few dark spots.
- **Signs**—Clear signage indicates which areas are designated for specific purposes and which areas are off limits.
- **Fencing**—Physical barriers deter casual intruders or mark boundaries.
- **Barricades**—Physical barriers deter aggressive intruders or limit vehicle access.
- **Guards**—A physical presence can deter intrusion, and humans can react quickly to changing conditions.
- **Motion detectors**—Devices generate an alert when motion is observed in a small, defined area.
- **Video surveillance**—Devices monitor many areas of a facility from a central location and record actions for later analysis.
- **Locks**—Physical devices limit physical access from unauthorized personnel. Lock controls can include door locks, cable locks, safes, and locking cabinets.
- **Mantraps**—Mantraps are two sets of doors with a small alcove between them. A person must pass through the first set of doors and allow them to close and lock before the second set of doors will open. A mantrap provides a convenient way to control physical access to a secure space.
- **Access lists**—These lists comprise the names of personnel authorized to access a physical resource.

- **Proximity readers**—Sensors can read smart cards or devices that are close to the reader to grant access to secure areas or resources to any individual carrying the proper device or smart card.
- **Biometrics**—Biometrics are a form of access control based on physical characteristics or actions.
- **Protected access (cabling)**—Protected access involves limiting connectivity to secure IT components by restricting access to connecting cabling.
- **Alarms**—Alarms refer to any signal generated by a control that matches a list of events that warrant immediate action.

Environmental and physical controls are not solely dedicated to security. One important part that most of these controls play is that of personnel safety. All the controls listed previously contribute to a safe environment for personnel. Additionally, a robust personnel safety plan should include the following:

- **Escape plans**—An escape plan is a primary personnel safety plan that tells each person how to escape in the face of a disruption, including where to go once outside the immediate danger area.
- **Escape routes**—In addition to an escape plan, personnel need to know the best routes to use to escape a disruption. Ideally, each escape route should end up at a defined rally point to allow management to determine whether anyone is missing.
- **Drills**—Drills are crucial walk-through tests of personnel safety plans and are essential for all personnel in order to know how to react in the face of a disruption.
- **Control testing**—All controls, regardless of type, should be periodically tested to ensure that they are performing as designed.

Pricing/Costing a Countermeasure

Many factors must be considered in evaluating countermeasures:

- **Product costs**—The price of the product will include its base price, the price of additional features, and costs associated with the service-level agreement or annual maintenance.
- **Implementation costs**—Implementation costs refer to those associated with changes to the infrastructure, construction, design, and training. An example is the cost of reinforcing a floor to install new equipment.
- **Compatibility costs**—The countermeasure must fit within (be compatible with) the overall structure. For example, a Windows-only organization would have to carefully consider the additional costs associated with training and interoperability when installing a Linux-based countermeasure.
- **Environmental costs**—If, for example, a countermeasure uses a lot of energy, consideration must be given to whether the electrical system would be able to provide that energy and to offset the excess heat it will generate.
- **Testing costs**—Testing takes time and money and causes disruptions, the costs of which must be considered.
- **Productivity impact**—Many controls affect productivity, such as generating more calls to the help desk or slowing response times for users.

TIP

Remember, the cost of a countermeasure is more than just the purchase price of a piece of technology.

Monitor and Control Risk Response

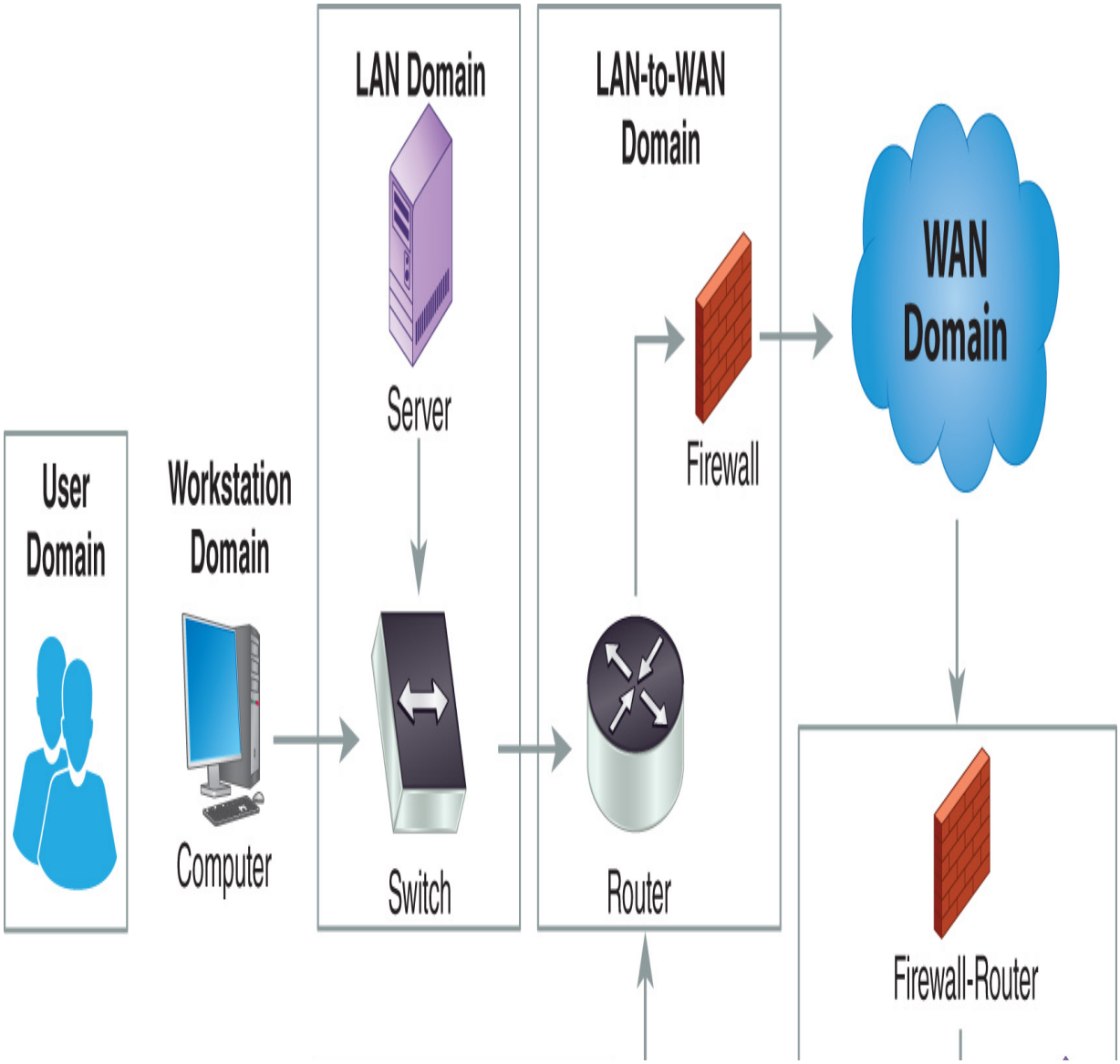
The most important part of putting any control or countermeasure in place is making sure it meets its objectives. Therefore, the last step in the risk management process is to monitor and control deployed countermeasures to determine whether they are providing their intended benefits.

When evaluating a countermeasure, first ask "What problem is this countermeasure designed to solve?" (The risk management plan should make this clear.) Then ask "Does this countermeasure solve this problem?" Here are some other points to consider:

- **Countermeasures might pose a new risk to the organization**—For example, implementing a countermeasure might create a false sense of security, or the countermeasure itself might become a new point of failure on a critical system. Make sure the countermeasure is continuously monitored, checked for compliance and good design, and regularly maintained.
- **Perform certification and accreditation of countermeasure programs**—All systems, controls, and applications should first go through a change control process before going into production, and this also applies to making changes to existing production systems. Otherwise, administrators might misconfigure the system or make other errors.
- **Follow best practices and exercise due diligence**—A good risk management program tells auditors that the company is taking a prudent and diligent approach to security risks. Due diligence is exercised by frequently evaluating whether countermeasures are performing as expected.

IT and Network Infrastructure

Now, let's focus our attention on risk to IT and the network infrastructure, of which hardware and software are key pieces. **FIGURE 3-7** shows the seven domains of a typical IT infrastructure framework, the components of which connect to a network or to the Internet. Because it is connected to the Internet, both internal and external threats to the IT infrastructure exist. Moreover, vulnerabilities, which are weaknesses in the design, implementation, or software of the IT infrastructure assets, can also exist.



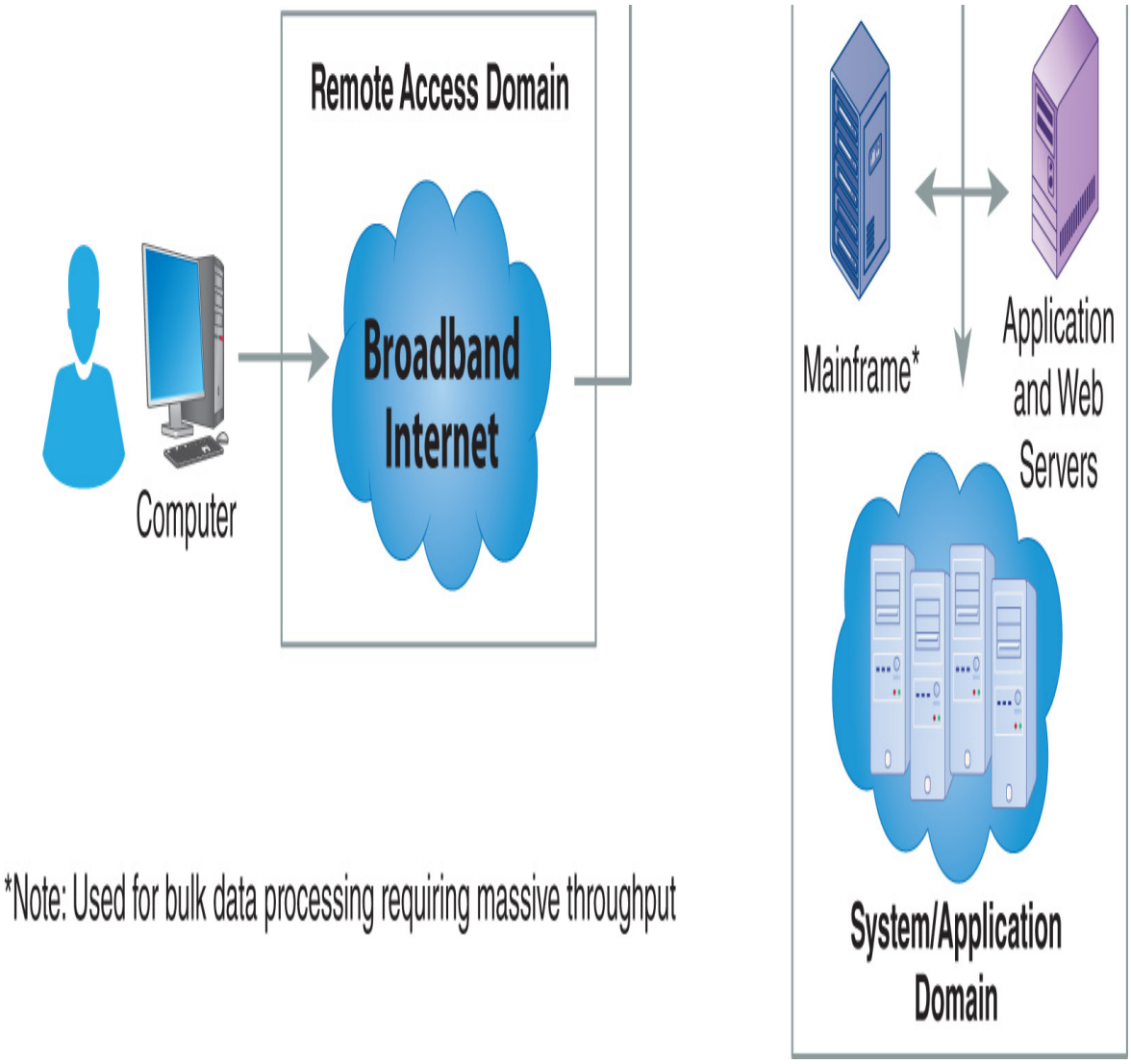


FIGURE 3-7 The seven domains of a typical IT infrastructure.

Damage to data caused by new threats includes armored viruses, ransomware, and cryptolocker malware, each of which can cost corporations time and money to fix or replace. Armored viruses have hardened code that makes it difficult to reverse engineer and build an antivirus solution; ransomware is a new form of malware linked to a time clock, forcing the victim organization to pay a ransom to prevent its data from being deleted, and cryptolocker is a specific form of ransomware that encrypts critical files or data until the victim pays a ransom to obtain the decryption keys.

Malicious threats on critical hardware and software systems can also lead to more widespread problems within organizations and can include loss of

critical data or theft of financial information or intellectual property. Unprotected IT and network infrastructure assets can offer attackers and cybercriminals the widest opening to access sensitive resources. Moreover, because of the ease of access to assets that are connected to the Internet, they are the most common first point of attack.

NOTE

In February 2016, Hollywood Presbyterian Medical Center was a victim of ransomware using a cryptolocker malware application. Cryptolocker malware locks systems by encrypting critical files and demanding a ransom to obtain the decryption key. The center elected to pay the ransom of $17,000 using Bitcoin to obtain the decryption keys and return to normal operations. No data breach occurred, but the incident resulted in a complete loss of control of all computer systems given that critical files were encrypted and thus rendered unusable.

Because of the potential for malicious threats to succeed with Internet-connected assets, the most valuable assets should be hidden under a layered security defense deep inside the IT infrastructure. Layered security defense, also known as *defense in depth*, is critical given the sophistication of new, polymorphic malware, which is particularly harmful given that it can morph, or change, thus making it difficult to see and remediate with antivirus or anti-malware solutions.

Intellectual Property

Intellectual property is the central asset of many organizations, such as a unique business process or actual data (e.g., customer data). Examples of intellectual property include such things as patents, drug formulas, engineering plans, sales and marketing plans, scientific formulas, and recipes. Suppose a restaurant chain has a unique process for quickly preparing and delivering food. If the rest of the industry knew about that

process, it would remove the restaurant's competitive advantage. In a digital world, data constitutes the most valuable asset. The more data a company has, the more valuable the company is. And, if a company has metadata for its data, its data is even more valuable.

What has often been in the news headlines? That data breaches or data losses are occurring every day in every aspect of life. This type of loss includes identity, business, or intellectual property theft. As an information systems security professional, it is your mission to prevent a data breach from occurring to your assets. *That* is your number one objective.

The core issue from an IT security perspective is protecting against the theft of intellectual property and preventing its release to competitors or to the public because its theft can nullify an organization's competitive advantage. Imagine that a company called Alpha Drug Company invested $2 billion to develop a new prescription drug, with the expectation that it would earn $10 billion when it releases the drug. Now, imagine that just as Alpha Drug Company was set to bring its medication to market, Beta Drug Company obtained Alpha's formulas and rushed its own version to market. Alpha would lose the first-to-market advantage given that it invested in R&D and a big chunk of the revenue associated with the new drug. As evidenced in this example, protecting intellectual property is a top-of-mind consideration for any organization.

Finances and Financial Data

Financial assets are among the highest-profile assets in any organization. They can be real financial assets, such as bank accounts, trading accounts, purchasing accounts, corporate credit cards, and other direct sources of money or credit. Alternatively, they can be data that allows access to real financial assets. Financial data can include customer credit card numbers, personal financial information, employee payroll information, actual payroll payments, or usernames and passwords used to access banking or investment accounts. Other examples include the transaction data that companies and banks use to transfer financial data between themselves, such as electronic data interchange (EDI) numbers or automated clearinghouse (ACH) transactions used for electronic payments or transfer of funds.

Loss of financial assets due to malicious attacks is a worst-case scenario for all organizations. Not only does it represent significant physical loss, but it can also have long-term effects on a company's reputation and brand image.

Service Availability and Productivity

Computer applications provide specific services that help organizations conduct business operations. It is important that critical services be available for use when organizations need them. *Downtime*, either intentional or unintentional, is the time during which a service is not available due to failure or maintenance. Often, administrators will schedule intentional downtime in advance. For example, when servers need operating system upgrades or patches, administrators take them offline intentionally so they can perform the necessary work without problems. When administrators schedule intentional downtime, they try to do so when it will have little impact on the rest of the organization. Administrators carefully manage any impact that downtime does have so that it does not disrupt critical business operations. You might be familiar with intentional downtime scenarios such as weekend upgrades of critical software or overnight application of patches to such things as email systems.

Unintentional downtime is usually the result of technical failure, human error, or attack, of which technical failure and human error are the most common causes. Although downtime caused by malicious attacks is less common, research indicates that it is growing rapidly. Malicious attacks can occur and cause downtime in any of the seven domains of a typical IT infrastructure, but typically, they are targeted on the User, Workstation, LAN, and LAN-to-WAN Domains.

Opportunity cost, also referred to as *true downtime cost*, is the amount of money a company loses due to either intentional or unintentional downtime. Opportunity cost usually measures the loss of productivity experienced by an organization due to downtime and, hence, why availability is an important tenet of information systems security. For example, suppose a major airline's reservation servers fail. While the servers are down, no customers can book flights; thus, the opportunity cost of that downtime can be measured in the dollar amount of the unsold tickets. The opportunity cost of unintentional

downtime is usually much higher than that of intentional downtime, but all opportunity costs are a serious concern for information security professionals. Such costs comprise a large portion of the $1 trillion estimated yearly cost of dealing with cybercrime and malicious attacks.

NOTE

A data breach policy and procedure will prepare an organization for handling a data breach and includes communicating to the customers, regulatory bodies, and insurance underwriters. If an organization is under regulatory compliance requirements, it may be subject to legal requirements for data breach notification within a set time period. Executive managers, including legal staff, are typically involved in making specific recommendations regarding a data breach to the organization's board of directors. Proper handling of a data breach must be done with relevant legal advice, especially if that organization is subject to regulatory compliance laws or state laws for loss of citizen data.

Reputation

One of the most important things that information security professionals try to protect is their organization's reputation and brand image. Companies that suffer from security breaches and malicious attacks that expose any assets are likely to face serious negative consequences in the public eye. For example, a security breach that allows attackers to steal customer credit card data and distribute that data internationally would do significant harm to that company's reputation and brand image. Even if the company's response were swift and solved the problem effectively, the negative public perception of the company and its brands could remain for a long time. Among other consequences, negative public perception could lead to a decline in the organization's revenue, net worth, and market capitalization.

Who Are the Perpetrators?

In popular usage and in the media, the term **hacker** often describes someone who breaks into a computer system without authorization. In most cases that means the hacker tries to take control of a remote computer through a network or by software cracking. The media and the general public also use the word *hacker* to describe anyone accused of using technology for terrorism, vandalism, credit card fraud, identity theft, intellectual property theft, or one of many other forms of crime. In the computing community, the term *hacker* generally describes a person who enjoys exploring and learning how to modify something, particularly related to computer systems. Hackers, for good or bad, are considered to be experts and tinkerers. Bad hackers are perpetrators who pose a threat to an organization, hence why the term *hacker* is often the subject of controversy.

The term ***ethical hacker*** means the hacker is performing computer hacking with preauthorization from the organization in an attempt to test and circumvent security controls that may or may not be implemented. Organizations hire ethical hackers when performing penetration testing on an IT infrastructure and its network and assets.

This text attempts to address the confusion surrounding this term by defining the different types of hackers as follows:

- **Black-hat hackers**—Black-hat hackers try to break IT security and gain access to systems with no authorization in order to prove technical prowess or potentially steal sensitive data. They develop and use special software tools to exploit vulnerabilities and holes in systems but do not attempt to disclose vulnerabilities they find to the administrators of those systems. Moreover, they tend to promote the free and open use of computing resources as opposed to the notion of security.
- **White-hat hackers**—White-hat, or ethical, hackers are information systems security professionals who have authorization to identify vulnerabilities and perform penetration testing. The difference between white-hat and black-hat hackers is that white-hat hackers will identify

weaknesses for the purpose of fixing them and black-hat hackers find weaknesses just for the fun of it or to exploit them.

- **Gray-hat hackers**—Gray-hat hackers are hackers with average abilities who may one day become black-hat hackers but could also opt to become white-hat hackers. Another common definition is hackers who will identify but not exploit discovered vulnerabilities yet may still expect a reward for not disclosing the vulnerability openly. There is no generally agreed upon definition for this type of hacker.

NOTE

Another type of hacker is a *script kiddie*—wannabe hackers of any age with little or no skill. They simply follow directions or use a "cookbook" approach to carry out a cyberattack, without fully understanding the meaning of the steps they are performing. Script kiddies typically learn hacking techniques by watching YouTube videos and then attempt to follow the instructions on real IT infrastructures.

Hackers are different from crackers. *Crackers* have a hostile intent, possess sophisticated skills, may be interested in financial gain, and represent the greatest threat to networks and information resources. These threats usually involve fraud, theft or destruction of data, blockage of access, and other malicious activity. However, the activities of crackers can also cause damage and loss but may not be financially motivated.

Risks, Threats, and Vulnerabilities in an IT Infrastructure

Risks, threats, and vulnerabilities go together. Risk is the probability that something bad is going to happen, a threat is any action that can damage or compromise an asset, and a vulnerability is a weakness in the design or software code itself. If a vulnerability can be exploited, it is a threat.

Because software for all IT assets has bugs or vulnerabilities, many software vendors limit their liability with a stringent End-User Licensing Agreement (EULA). For example, Microsoft has a $5.00 maximum limitation of liability clause once you install an application using a valid product license number. The EULA is what transfers software companies' risk to its end users from having vulnerable software and being held liable for a software vulnerability.

The bugs or errors in software can lead to an exploitable software vulnerability. Hackers continuously look for known software vulnerabilities as a means to find an exploitable weakness that allows for unauthorized access or other asset compromise. Using vulnerability assessment scanners, such as Qualys®, Nessus®, OpenVAS, and Nikto, helps organizations identify software vulnerabilities. Such vulnerability scanners are preloaded with the Common Vulnerabilities and Exposures (CVE) database; they can provide an up-to-date vulnerability scan on all known IT assets, during which any known software vulnerabilities will be identified.

NOTE

You should become familiar with the National Vulnerability Database (NVD) website, which can be found at *https://nvd.nist.gov*. The NVD is the U.S. government repository of software vulnerability data. The NVD includes information from the MITRE Corporation's CVE list of all known software vulnerabilities and exploits, which enables vulnerability

assessment scanners to be automatically updated with the latest information. In addition, the NVD includes security checklist references, security-related software flaws, misconfigurations, product names, and impact metrics.

Hackers commonly perform a vulnerability assessment scan on IP hosts as part of their initial reconnaissance, the results of which provide known IP hosts, open ports, and software vulnerabilities that may be exploitable. If they find a known exploit, they use exploit tools, such as Metasploit, to automate a sequence of hacking steps, making performing timely patching on IT assets in the IT infrastructure a race against time. Patching software vulnerabilities before they can be found and exploited by hackers requires a sound vulnerability management and patch management program. The risk introduced by software vulnerabilities is high and increases every day the IT asset remains unpatched. The gap in time between the announcement of a vulnerability and the application of a patch is referred to as the *vulnerability window*.

The term *zero-day vulnerability* refers to the fact that a software manufacturer may announce to the public that a software vulnerability exists but not yet a patch, a situation that leaves the production IT asset completely exposed if no other compensating security controls can be deployed. **Zero day** refers to a vulnerability window of zero days because there is no patch yet for a known software vulnerability. Examples of zero-day vulnerabilities are published by the zero-day initiative: *www.zerodayinitiative.com/advisories/published/*.

If a vulnerability exists in a system, so does the possibility of a threat. Any threat against a vulnerability creates a risk that a negative event may occur. You cannot eliminate threats, but you can protect against vulnerabilities. That way, even though a threat still exists, it cannot exploit the vulnerability. The key to protecting assets from the risk of attack is to eliminate or address as many vulnerabilities as possible.

You can find many threats and vulnerabilities within an IT infrastructure. **TABLE 3-2** lists some of the common ones found within each of the seven domains of an IT infrastructure. A threat to a computing device (which can come from an individual, a group of individuals, or an organization) is any

action, either accidental or malicious, that can have a negative effect on the assets and resources of an individual or organization. The asset might be hardware, software, databases, files, data, or the physical network itself.

FYI

Identifying and responding to threats and vulnerabilities can be a complicated process. In some cases, a threat may be too expensive or require too much time to eliminate. Your goal should be to reduce the occurrence of as many threats as possible but also to carefully assess whether the cost of protecting some assets is greater than the value of the assets themselves. You do not want to spend more time and money identifying and responding to threats than the assets are actually worth.

TABLE 3-2 Common threats and vulnerabilities in the seven domains of an IT infrastructure.

DOMAIN	COMMON THREATS AND VULNERABILITIES
User Domain	Lack of awareness or concern for security
	Accidental acceptable use policy violation
	Intentional malicious activity
	Social engineering and phishing email attacks
Workstation Domain	Unauthorized user access
	Malicious software introduced
	Weaknesses in installed software due to a software vulnerability
LAN Domain	Unauthorized network access
	Transmitting private data unencrypted
	Storing sensitive data on insecure LAN drives
	Spreading malicious software
LAN-to-WAN Domain	Exposure and unauthorized access to internal resources from the outside
	Introduction of malicious software
	Loss of productivity due to unavailable Internet access
WAN Domain	Transmitting sensitive data unencrypted
	Malicious attacks from anonymous sources
	Denial of service (DoS) or distributed denial of service (DDoS) attacks
	Weaknesses in network infrastructure or software

DOMAIN	COMMON THREATS AND VULNERABILITIES
Remote Access Domain	Brute-force password attacks on access and private data Unauthorized remote access to resources Data leakage from remote access or lost storage devices Delayed patching for remote workstations or laptops
System/Application Domain	Unauthorized physical or logical access to resources Weaknesses in server operating system or application software Data loss from errors, failures, or disasters Lack of proper digital certificates for use on production websites and portals

The goal of computer security is to provide insights, methodologies, and techniques that deal with threats, which are significant from a security viewpoint. This goal can be achieved by developing policies that help computer and network system administrators, designers, developers, and users to avoid undesirable system characteristics and weaknesses.

Threats can be identified and ranked according to their importance and impact, such as potential for dollar loss, negative reputation created, monetary liability, or how often they are likely to occur. Each organization may rank a threat higher or lower than another organization does, based on its impact to that organization.

Following are the most common threats, listed in no particular order:

- Malicious software
- Hardware or software failure
- Internal attacker
- Equipment theft
- External attacker
- Natural disaster
- Industrial espionage
- Terrorism

Not all threats are malicious. Although some threats may be intentional, others may be accidental, such as hardware failure or a software problem caused by a lack of controls. However, the results of accidental threats can be just as damaging as malicious threats. Therefore, you must make every

effort to minimize all security breaches, whether malicious or accidental. The overall goal is to protect the network and computer system from any attack and to prevent the theft, destruction, and corruption of individual or organizational assets.

Threat Targets

Using their favorite search engines, attackers can find precise instructions for breaching nearly any protocol, operating system, application, device, or hardware environment. For this reason, you must monitor all threats very closely. You never know where one might come from next. It may be a professional cybercriminal or someone within your own four walls. The safest bet is to monitor all threat targets constantly and carefully.

The first step in developing a monitoring plan is to identify where in the seven domains of an IT infrastructure threats are likely to occur. **TABLE 3-3** lists many common threat targets and where they are found in an IT infrastructure.

TABLE 3-3 Threat targets in the seven domains of an IT infrastructure.

DOMAIN	THREAT TARGET
User Domain	Employees' own human traits and behavior Violations of the acceptable use policy are targeted.
Workstation Domain	Workstations, laptops, and mobile devices along with their vulnerabilities Is the point of entry into the IT infrastructure, and hence why audit trails and log capturing and monitoring are essential
LAN Domain	Windows Active Directory/domain controllers, file servers, print servers Networks running the IP are part of the LAN Domain and are a target for ID and authentication attacks.
LAN-to-WAN Domain	Public-facing IP devices, including perimeter security with firewalls, IDS/IPS, and remote virtual private network (VPN) terminations Demilitarized zone (DMZ) virtual LANs (VLANs) or dedicated remote connections are typically terminated here.
WAN Domain	IP routers, Transmission Control Protocol/Internet Protocol (TCP/IP) stacks and buffers, firewalls, gateways, switches, and wide area network (WAN) service providers are targeted.

DOMAIN	THREAT TARGET
Remote Access Domain	VPNs, multifactor authentication, and remote access for mobile workers and teleworkers are typically supported and targeted.
System/Application Domain	Web and application servers, operating systems, and applications Back-end database servers and database tables with sensitive data are the target.

From this list, it should be clear that there are many opportunities for an attacker to cause big problems and that many of the threat targets appear in different categories. Thus, the need for a comprehensive security plan across all domains should also be clear.

Threat Types

To secure information, you must protect its confidentiality, integrity, and availability (C-I-A). The following three major threat types directly threaten each of the C-I-A tenets:

- Disclosure threats
- Alteration threats
- Denial or destruction threats

Disclosure Threats

Disclosure occurs any time unauthorized users access private or confidential information that is stored on a network resource or while it is in transit between network resources. Attackers can use software, called a packet sniffer, to collect and analyze network packets, looking for private or confidential data. Disclosure can also occur when a computer or device containing private or confidential data, such as a database of medical records, is lost or stolen. Following are two techniques that attackers employ to illegally obtain or modify data:

- **Sabotage**—Sabotage is the destruction of property or obstruction of normal operations. Technically, sabotage attacks the availability property of information security.

- **Espionage**—Espionage is the act of spying to obtain secret information, typically to aid another nation-state. Terrorists and enemy agents might well be involved in activities to obtain sensitive government information that they can use to perpetrate future attacks.

NOTE

An *information leak* is any instance of someone who purposely distributes information without proper authorization.

Sabotage is not a silent attack, but espionage can occur without any obvious trace.

In many organizations, a great deal of stored information is unavailable to the public. This information can include personal information on a user's computer or confidential records stored in a massive database. The effects of the disclosure of this information can vary. For example, where the disclosure of a user's personal information could cause embarrassment, public disclosure of a citizen's private records could result in severe repercussions. In addition, disclosing information could cause even more problems if government secrets or intelligence files are involved.

Information security personnel devote much time and effort to combating disclosure threats. In particular, the U.S. government focuses very closely on disclosure threats because of their potential to cause problems for critical security areas. One of the most difficult things about combating these types of threats, however, is that unauthorized users can intercept unprotected data without leaving any trace of their activities. For this reason, security research and development have focused on the disclosure threat and its countermeasures.

Alteration Threats

An alteration threat violates information integrity. This type of attack compromises a system by making unauthorized changes to data, either intentionally or unintentionally. These changes might occur while the data is

stored on a network resource or while it is moving between two resources. Intentional changes are usually malicious, whereas unintentional changes are usually accidental. People can, and often do, make mistakes that affect the integrity of computer and network resources. Even so, unintentional changes still create security problems.

Modifications to the system configuration can also compromise the integrity of a network resource. Such a modification can occur when an unauthorized party tampers with an asset or an authorized user makes a change that has unintended effects. For example, a user might modify database files, operating systems, application software, and even hardware devices. Such modifications might include creating, changing, deleting, and writing information to a network resource. It's a good idea to put techniques in place that enable the tracking or auditing of these changes as they happen. That way, a record exists of who, what, when, where, and how modifications were made. In addition, change management systems limit who can make changes, how the changes can be made, and how the changes are to be documented. It is very important that only authorized parties change assets and only in authorized ways.

Is It Really a DoS Threat?

A DoS attack is not the only cause for a system's poor response time. It could be caused by simple user error or *oversubscription* of network facilities, which means that more computers or processes are using a network than were intended. Network vendors use this technique to increase revenue at the user's expense by allowing more paying customers to consume bandwidth, which can result in slower performance than advertised. Alternatively, the provider may be causing a user's inability to reach a network resource. For example, the provider may have taken key resources offline to perform a system update or website modification. Yet another culprit might be *throttling*, a technique some administrators use to reduce network traffic.

Advance preparation can reduce the severity of alteration threats. For example, if there is a backup or copy of the data, then the impact of a breach

may be less severe than if a backup were not available. However, data recovery should always be the last resort. A far better approach is to avoid an alteration attack in the first place because protecting information is always better than repairing or recovering it.

Denial or Destruction Threats

Denial or destruction threats make assets or resources unavailable or unusable. Any threat that destroys information or makes it unavailable violates the availability tenet of information security. A denial or destruction attack is successful when it prevents an authorized user from accessing a resource, either temporarily or permanently.

A DoS attack is an example of a usually malicious denial or destruction threat that prevents authorized users from accessing computer and network resources. Many organizations are potential victims of DoS attacks. In fact, any computer connected to the Internet is a DoS threat candidate. This type of attack can represent a minor problem or a great danger, depending on the importance of the blocked asset or resource. For example, suppose an attacker floods a specific port on a server. If the port is not for a critical resource, the impact may be minimal. However, if the port supports authorized user access to a company's website, it could prevent customers from accessing it for minutes or hours. In that case, the impact could be severe.

WARNING

Even if a DoS attack floods a noncritical port, the excess traffic could cause the server to crash or become so slow that it cannot service legitimate requests in a timely manner. In this case, the DoS attack is still successful.

What Is a Malicious Attack?

A **malicious attack** is a threat on an IT infrastructure. An attack on a computer system or network asset succeeds by exploiting a vulnerability or weakness in the design, system, or application. An attack can consist of all or a combination of the following four categories:

- **Fabrications**—Fabrications involve the creation of some deception in order to trick unsuspecting users.
- **Interceptions**—Interceptions involve eavesdropping on transmissions and redirecting them for unauthorized use.
- **Interruptions**—Interruptions cause a break in a communication channel, which blocks the transmission of data.
- **Modifications**—Modifications are the alteration of data contained in transmissions or files.

As stated earlier, security threats can be either active or passive, but both types can have negative repercussions for an IT infrastructure. An active attack is a physical intrusion that involves modifying the data stream or attempting to gain unauthorized access to computer and networking systems. In a passive attack, the attacker does not make changes to the system but rather does such things as eavesdropping or monitoring actual data transmissions.

Following are examples of active threats:

- Birthday attacks
- Brute-force password attacks
- Credential stuffing
- Dictionary password attacks
- IP address spoofing
- Hijacking
- Replay attacks

- Man-in-the-middle attacks
- Masquerading
- Social engineering
- Phreaking
- Phishing
- Pharming

A growing number of these attacks appear on information systems security professionals' radar screens every year. Following is a description of several of the most common types of malicious attacks.

Birthday Attacks

Once an attacker compromises a hashed password file, a birthday attack is performed. A birthday attack is a type of cryptographic attack that is used to make a brute-force attack of one-way hashes easier. It is a mathematical exploit that is based on the birthday problem in probability theory.

Brute-Force Password Attacks

One of the most tried-and-true attack methods is a **brute-force password attack**. In this type of attack, the attacker employs a software program to try all possible combinations of a likely password, user ID, or security code until it locates a match. This process occurs rapidly and in sequence. This type of attack is called a brute-force password attack because the attacker simply hammers away at the code. There is no skill or stealth involved—just brute force that eventually breaks the code.

With today's large-scale computers, it is possible to try millions of combinations of passwords in a short period of time. Given enough time and using enough computers, it is possible to crack most algorithms.

Credential Harvesting and Stuffing

When hackers steal or obtain logon IDs and passwords, the next step to is to gain unauthorized access by attempting to log on to a web application using

the compromised logon IDs and passwords. This attack is referred to as **credential harvesting** or credential stuffing.

Hackers attempt to gain unauthorized access by trying the stolen logon credentials on public-facing web applications, one logon ID and password at a time. This type of attack can be automated. Given enough time, hackers will be successful in gaining unauthorized access with one or several combinations of logon credentials.

Dictionary Password Attacks

A *dictionary password attack* is a simple attack that relies on users making poor password choices. In a dictionary password attack, a simple password-cracker program takes all the words from a dictionary file and attempts to log on by entering each dictionary entry as a password.

Users often engage in the poor practice of selecting common words as passwords. A password policy that enforces complex passwords is the best defense against a dictionary password attack. Users should create passwords composed of a combination of letters and numbers, and the passwords should not include any personal information about the user.

IP Address Spoofing

Spoofing is a type of attack in which one person, program, or computer disguises itself as another person, program, or computer to gain access to a resource. A common spoofing attack involves presenting a false network address to pretend to be a different computer. An attacker may change a computer's network address to appear as an authorized computer in the target's network. If the administrator of the target's local router has not configured it to filter out external traffic with internal addresses, the attack may be successful. IP address spoofing can enable an attacker to access protected internal resources.

NOTE

A CERT advisory on IP spoofing reports that the CERT Coordination Center has received reports of attacks in which intruders create packets with spoofed source IP addresses. This exploit leads to user impersonation and escalated privilege access on the target system, which means that the intruder can take over logon connections and create havoc.

Address resolution protocol (ARP) poisoning is an example of a spoofing attack. In this attack, the attacker spoofs the Media Access Control (MAC) address of a targeted device, such as a server, by sending false ARP resolution responses with a different MAC address. This causes duplicate network traffic to be sent from the server. Another type of network-based attack is the Christmas (Xmas) attack. This type of attack sends advanced TCP packets with flags set to confuse IP routers and network border routers with TCP header bits set to 1, thus lighting up the IP router like a Christmas tree.

Hijacking

Hijacking is a type of attack in which the attacker takes control of a session between two machines and masquerades as one of them. Following are examples of the types of hijacking:

- **Man-in-the-middle hijacking**—In this type of hijacking (discussed in more detail subsequently), the attacker uses a program to take control of a connection by masquerading as each end of the connection. For example, if Mary and Fred want to communicate, the attacker pretends to be Mary when talking with Fred and pretends to be Fred when talking to Mary. Neither Mary nor Fred know they are talking to the attacker. Thus, the attacker can collect substantial information and even alter data as it flows between Mary and Fred by either gaining access to the messages or modifying them before retransmitting. A man-in-the-middle attack can occur from an insider threat, such as from an employee, contractor, or trusted person within the organization.
- **Browser or URL hijacking**—In a browser or URL hijacking attack, also known as *typosquatting*, users are directed to websites other than

what they requested, usually to fake pages that attackers have created. This gives the users the impression that the attacker has compromised the website when in fact the attacker has simply diverted the users' browsers from the actual site. Attackers can use this attack with phishing (discussed later in this chapter) to trick a user into providing private information, such as a password.

FYI

Session hijacking reveals the importance of identifying the other party in a session. It is possible for an intruder to replace a legitimate user for the remainder of a communication session. This calls for a scheme to authenticate the data's source throughout the transmission. In fact, authenticating both ends of a connection, a process called *mutual authentication*, could reduce the potential of an undetected hijack. However, even the strongest authentication methods are not always successful in preventing hijacking attacks. That means you might need to encrypt all transmissions.

- **Session hijacking**—In session hijacking, the attacker attempts to take over an existing connection between two network computers. The first step in this attack is for the attacker to take control of a network device on the local area network (LAN), such as a firewall or another computer, in order to monitor the connection. Taking control of this device enables the attacker to determine the sequence numbers used by the sender and receiver, after which the attacker generates traffic that appears to come from one of the communicating parties, in essence stealing the session from one of the legitimate users. To get rid of the legitimate user who initiated the hijacked session, the attacker overloads one of the communicating devices with excess packets so that it drops out of the session.

Replay Attacks

Replay attacks involve capturing data packets from a network and retransmitting them to produce an unauthorized effect. The receipt of duplicate, authenticated IP packets may disrupt service or produce another undesired consequence. Systems can be broken through replay attacks when attackers reuse old messages or parts of old messages to deceive system users. Breaking a system this way helps intruders to gain information that allows unauthorized access into the system.

Man-in-the-Middle Attacks

A **man-in-the-middle attack** takes advantage of the multihop process used by many types of networks. In this type of attack, an attacker intercepts messages between two parties before transferring them on to their intended destination.

Web spoofing is a type of man-in-the-middle attack in which the user believes a secure session exists with a particular web server. In reality, the secure connection exists only with the attacker, not the web server. The attacker then establishes a secure connection with the web server, acting as an invisible go-between, passing traffic between the user and the web server. In this way, the attacker can trick the user into supplying passwords, credit card information, and other private data.

Attackers use man-in-the-middle attacks to steal information, execute DoS attacks, corrupt transmitted data, gain access to an organization's internal computer and network resources, and introduce new information into network sessions.

Masquerading

In a masquerade attack, one user or computer pretends to be another user or computer. Masquerade attacks usually include one of the other forms of active attacks, such as IP address spoofing or replaying. Attackers can capture authentication sequences and then replay them later to log on again to an application or operating system. For example, an attacker might monitor usernames and passwords sent to a weak web application and then use the intercepted credentials to log on to the web application and impersonate the user.

NOTE

Masquerade attacks can involve other credentials as well. For example, many attackers get free wireless access by capturing wireless packets from paying customers. They use information in the packets to masquerade as a paying customer and connect to the wireless network free of charge.

Eavesdropping

Eavesdropping, or **sniffing**, occurs when a host sets its network interface on promiscuous mode and copies packets that pass by for later analysis. Promiscuous mode enables a network device to intercept and read each network packet, even if the packet's address does not match the network device. It is possible to attach hardware and software to monitor and analyze all packets on that segment of the transmission media without alerting any other users. Candidates for eavesdropping include satellite, wireless, mobile, and other transmission methods.

Social Engineering

Attackers often use a deception technique called **social engineering** to gain access to resources in an IT infrastructure. In nearly all cases, social engineering involves tricking authorized users into carrying out actions for unauthorized users. The success of social engineering attacks depends on the basic tendency of people to want to be helpful.

Social engineering places the human element in the security breach loop and uses it as a weapon. A forged or stolen vendor or employee ID could provide entry to a secure location. The intruder could then obtain access to important assets. By appealing to employees' natural instinct to help a technician or contractor, an attacker can easily breach the perimeter of an organization and gain access.

Personnel who serve as initial contacts within an organization, such as receptionists and administrative assistants, are often targets of social

engineering attacks. Attackers with some knowledge of an organization's structure will often also target new, untrained employees as well as those who do not seem to understand security policies.

Eliminating social engineering attacks can be difficult, but here are some techniques to reduce their impact:

- Ensure that employees are educated on the basics of a secure environment.
- Develop a security policy and computer use policy.
- Enforce a strict policy for internal and external technical support procedures.
- Require the use of identification for all personnel.
- Limit the data accessible to the public by restricting the information published in directories, yellow pages, websites, and public databases.
- Be very careful when using remote access. Use strong validation so you know who is accessing your network.
- Teach personnel the techniques for sending and receiving secure email.
- Shred all documents that may contain confidential or sensitive information.

Phreaking

Phone phreaking, or simply phreaking, is a slang term that describes the activity of a subculture of people who study, experiment with, or explore telephone systems, telephone company equipment, and systems connected to public telephone networks. Phreaking is the art of exploiting bugs and glitches that exist in the telephone system.

Phishing

Scams are a growing problem on the Internet, one of which is **phishing**. In this type of fraud, an attacker attempts to trick the victim, via email or instant message, into providing private information, such as credit card numbers, passwords, dates of birth, bank account numbers, automated teller machine (ATM) PINs, and Social Security numbers, in order to commit identity theft.

The message appears to come from a legitimate source, such as a trusted business or financial institution, and includes an urgent request for personal information. Phishing messages usually indicate a critical need to update an account (e.g., banking or credit card) immediately. The message instructs the victim to either provide the requested information or click on a link provided in the message. Clicking the link leads the victim to a spoofed website, which looks identical to the official site but in fact belongs to the scammer. Personal information entered into this webpage goes directly to the scammer, not to the legitimate organization.

NOTE

Many social engineering activities occurring today have their basic roots in strategies developed by phreakers. In fact, several current social engineering attacks bear names that begin with the letters *ph* to pay homage to these social engineering pioneers.

A variation of the phishing attack is spear phishing. This attack uses email or instant messages to target a specific organization, seeking unauthorized access to confidential data. As with the messages used in regular phishing attempts, spear-phishing messages appear to come from a trusted source.

How to Identify a Phishing Scam

It may be difficult to identify a phishing scam simply by looking at the webpage that opens when you click a link in an email message. However, sometimes clues in the sender's address can reveal the deception. Look for the following:

- Phishers often substitute similar-looking characters for the real characters in a URL. For example, they might use a 1 (numeral one) in place of a lowercase *L*—think *paypa1.com* rather than *paypal.com*.

- Phishing scams have become so sophisticated that phishers can appear to use legitimate links, including the real site's security certificate. Before clicking a link, you should preview it to see where it will take you. If you notice that the domain name looks odd, do not click the link. Instead, contact the legitimate website's customer service or technical support group and ask whether the link is valid. This approach takes more time, but it is far safer than just clicking through links without checking them.
- Some phishers purchase domain names that are similar to those of legitimate companies, for example, *walmartorder.com*. The real company is Walmart, but it does not include *order* in its domain name.
- One ploy is to use the same domain name but with .org rather than .com. The con artists who use these domain names then send out millions of emails requesting that consumers verify account information, birth dates, Social Security numbers, and so on. Inevitably, some computer users will respond. Be sure to carefully examine the entire domain name.

The best way to protect against phishing of any kind is to avoid clicking on a link directly provided by a suspect email. Supplying personal information when prompted to do so by an email or instant message is too easily done once the website is in front of you. If you believe the request might be legitimate, call the company's customer service department to verify the request before providing any information. If you do call the company, do not use any phone numbers contained in the suspect message. Even if the URL displayed in the message is legitimate, manually enter the web address in your browser rather than clicking on a link in the message.

NOTE

Anti-malware programs and firewalls cannot detect most phishing scams because they do not contain suspect code. Some spam filters even let phishing messages pass because they appear to come from legitimate sources.

The Anti-Phishing Working Group (APWG) is a global, pan-industrial law enforcement association focused on eliminating fraud and identity theft resulting from email spoofing of all types. For more information, visit the APWG website at *www.antiphishing.org*. In addition, the Federal Trade Commission (FTC) website (*www.ftc.gov*) offers advice for consumers and an email address for reporting phishing activity, plus a form to report identity theft.

Pharming

Pharming is another type of attack that seeks to obtain personal or private financial information through domain spoofing but does not use messages to trick victims into visiting spoofed websites that appear legitimate. Instead, pharming "poisons" a domain name on the domain name server (DNS), a process known as *DNS poisoning*. The result is that, when users enter the poisoned server's web address into their address bar, it navigates them to the attacker's site. The user's browser still shows the correct website, which makes pharming difficult to detect and therefore more serious. Where phishing attempts to scam people one at a time with an email or instant message, pharming enables scammers to target large groups of people at one time through domain spoofing.

What Are Common Attack Vectors?

Depending on the attacker's goal, many types of attack vectors can suit their needs and abilities. An attack vector is a specific type of attack that poses a threat against an IT infrastructure and can be summarized in three categories:

- **Attacks on availability**—These attacks impact access or uptime to a critical system, application, or data.
- **Attacks on people**—These attacks involve using coercion or deception to get another human to divulge information or to perform an action (e.g., clicking on a suspicious URL link or opening an email attachment from an unknown email address).
- **Attacks on IT assets**—These attacks include penetration testing, unauthorized access, privileged escalation, stolen passwords, deletion of data, or performing a data breach.

Social Engineering Attacks

Social engineering is the art of one human attempting to coerce or deceive another human into doing something or divulging information. We do this all the time in our day-to-day lives. Children social engineer their parents into giving permission or providing something they want. Spouses may social engineer their partners into doing a chore they are responsible for. Criminals and hustlers are no different: They use social engineering tactics to get humans to divulge information about themselves or someone else. This is key in order to obtain private data to perfect identity theft. Hackers also attempt to social engineer targeted employees into divulging information about IT systems or applications so that the hackers can gain access.

Hackers and perpetrators use many tactics to attempt to social engineer their victims. Following is a summary of social engineering attacks that may be used on a person or an organization:

- **Authority**—Using a position of authority to coerce or persuade an individual to divulge information.

- **Consensus/social proof**—Using a position that "everyone else has been doing it" as proof that it is okay or acceptable to do.
- **Dumpster diving**—Finding pieces of paper that may contain sensitive or private data for identity theft.
- **Familiarity/liking**—Interacting with the victim in a frequent way that creates a comfort, familiarity, and liking for an individual (e.g., a delivery person may become familiar to office workers over time) that might encourage the victim to want to help the familiar person.
- **Hoaxes**—Creating a con or a false perception to get an individual to do something or divulge information.
- **Impersonation**—Pretending to be someone else (e.g., an IT help desk support person, a delivery person, or a bank representative).
- **Intimidation**—Using force to extort or pressure an individual into doing something or divulging information.
- **Scarcity**—Pressuring another individual into doing something or divulging information for fear of not having something or losing access to something.
- **Shoulder surfing**—Looking over the shoulder of a person typing into a computer screen.
- **Smishing**—Performing a phishing attack using SMS (text) messages sent to a victim's mobile device.
- **Tailgating**—Following an individual closely enough to sneak past a secure door or access area.
- **Trust**—Building a human trust bond over time and then using that trust to get the individual to do something or divulge information.
- **Trusted users**—Users who have valid credentials may simply fail to be diligent or may be disgruntled, poorly trained, or even compromised. Valid users such as these can make a social engineering attacker's job easy.
- **Urgency**—Using urgency or an emergency stress situation to get someone to do something or divulge information (e.g., claiming that there's a fire in the hallway might get the front desk security guard to leave his or her desk).

- **Vishing**—Performing a phishing attack by telephone to elicit personal information; using verbal coercion and persuasion ("sweet talking") the individual under attack.
- **Whaling**—Targeting the executive user or most valuable employees, otherwise considered the "whale" or "big fish" (often called *spear phishing*).

Wireless Network Attacks

Wireless network attacks involve performing intrusive monitoring, packet capturing, and penetration tests on a wireless network. Given the rapid deployment of wireless network connectivity in both public and private places, the mobile user is under constant threat. Wireless networks may be compromised as a network access point into an IT infrastructure. Implementation of proper wireless networking security controls is the key to mitigating the risks, threats, and vulnerabilities that arise from wireless networks. Many tactics are used by hackers and perpetrators as they attempt to penetrate and attack wireless networks.

Following is a summary of wireless network attacks:

- **Bluejacking**—Hacking and gaining control of the Bluetooth wireless communication link between a user's earphone and smartphone device.
- **Bluesnarfing**—Packet sniffing communications traffic between Bluetooth devices.
- **Evil twin**—Faking an open or public wireless network to use a packet sniffer on any user who connects to it.
- **IV attack**—Modifying the initialization vector of an encrypted IP packet in transmission in hopes of decrypting a common encryption key over time.
- **Jamming/interference**—Sending radio frequencies in the same frequency as wireless network access points, to jam and interfere with wireless communications, and disrupting availability for legitimate users.
- **Near field communication attack**—Intercepting, at close range (a few inches), communications between two mobile operating system devices.

- **Packet sniffing**—Capturing IP packets off a wireless network and analyzing the TCP/IP packet data using a tool such as Wireshark®.
- **Replay attacks**—Replaying an IP packet stream to fool a server into thinking it is being authenticated.
- **Rogue access points**—Using an unauthorized network device to offer wireless availability to unsuspecting users.
- **War chalking**—Creating a map of the physical or geographic location of any wireless access points and networks.
- **War driving**—Physically driving around neighborhoods or business complexes looking for wireless access points and networks that broadcast an open or public network connection.

In addition to these specific attacks, hackers may also attempt to exploit weaknesses in the wireless encryption method used by the target: WEP (Wireless Encryption Protocol), WPA (Wi-Fi Protected Assets), or WPS (Wi-Fi Protected Setup).

Web Application Attacks

Web application attacks involve performing intrusive penetration tests on public-facing web servers, applications, and back-end databases. Given the rapid deployment of e-commerce and customer or member portals and websites, access to private data, sensitive data, and intellectual property is abundant. Many tactics are used by hackers and perpetrators when attempting to penetrate and attack web applications.

Web applications that are public facing on the Internet are subject to a host of web application attacks, including:

- **Arbitrary/remote code execution**—Having gained privileged access or system administration rights access, the attacker can run commands or execute a command at will on the remote system.
- **Buffer overflow**—Attempting to push more data than the buffer can handle, thus creating a condition where further compromise might be possible.

- **Client-side attack**—Using malware on a user's workstation or laptop, within an internal network, acting in tandem with a malicious server or application on the Internet (outside the protected network).
- **Cookies and attachments**—Using cookies or other attachments (or the information they contain) to compromise security.
- **Cross-site scripting (XSS)**—Injecting scripts into a web application server to redirect attacks back to the client. This is not an attack on the web application but rather on users of the server to launch attacks on other computers that access it.
- **Cross-site request forgery (CSRF)**—Leveraging an authenticated user session in a way that causes malicious code stored on a third-party site to cause a valid user to send malicious requests to the target website.
- **Directory traversal/command injection**—Exploiting a web application server; gaining root file directory access from outside the protected network; and executing commands, including data dumps.
- **Header manipulation**—Stealing cookies and browser URL information and manipulating the header with invalid or false commands to create an insecure communication or action.
- **Integer overflow**—Creating a mathematical overflow that exceeds the maximum size allowed. This can cause a financial or mathematical application to freeze or create a vulnerability and opening.
- **Lightweight Directory Access Protocol (LDAP) injection**—Creating fake or bogus ID and authentication LDAP commands and packets to falsely ID and authenticate to a web application.
- **Local shared objects (LSO)**—Using Flash cookies (named after the Adobe Flash player), which cannot be deleted through the browser's normal configuration settings. Flash cookies can also be used to reinstate regular cookies that a user has deleted or blocked.
- **Malicious add-ons**—Using software plug-ins or add-ons that run additional malicious software on legitimate programs or applications.
- **SQL injection**—Injecting Structured Query Language (SQL) commands to obtain information and data in the back-end SQL database.
- **Watering-hole attack**—Luring a targeted user to a commonly visited website on which has been planted the malicious code or malware, in

hopes that the user will trigger the attack with a unknowing click.

- **XML injection**—Injecting XML tags and data into a database in an attempt to retrieve data.
- **Zero day**—Exploiting a new vulnerability or software bug for which no specific defenses yet exist.

The Importance of Countermeasures

There are no simple measures to protect an organization from computer attacks. You must focus on countermeasures and implement security controls that can help mitigate the risk caused by threats and vulnerabilities. Detecting vulnerabilities, preventing attacks and threats from occurring, responding to the effects of successful attacks, and responding to security-related incidents can be daunting, but it is better than the alternative. Dealing with computer and network attacks is a cost of doing business in today's digital and Internet-connected world.

Although smart attackers and intruders continue to invent new methods of attacking computer and network resources, many are well known and can be defeated with a variety of available tools. The best strategy is to identify vulnerabilities and reduce them to avoid attacks in the first place.

Avoiding attacks should be the highest priority, but even so, some attacks will succeed. A response to an attack should be as aggressive, proactive, and reactive as the attack itself. Responding to attacks includes developing plans to rapidly restore computer and network resources, closing holes in the organization's defenses, and obtaining evidence for prosecution of offenders. Of course, the lessons learned from an attack should be used to protect the network from similar attacks.

Responding to attacks involves planning, policy, and detective work. Fortunately, law enforcement agencies, forensic experts, security consultants, and independent response teams are available to assist in responding to a security incident as well as prosecuting offenders. In addition, many organizations have special teams to handle security incidents when they occur. These security incident response teams (SIRTs) and managed security service providers (MSSPs) know how to recognize incidents and respond to them in a way that minimizes damage and preserves evidence for later action.

CHAPTER SUMMARY

Risks, threats, and vulnerabilities and how they impact the seven domains of an IT infrastructure and its assets are an everyday menace. It is essential that organizations and individual users identify their own risks, threats, and vulnerabilities and implement a plan to mitigate them. You learned about the reasons for and processes of risk management. You also learned about risk assessment, including the difference between a quantitative and a qualitative risk assessment as well as common responses to risk and how they can help to develop a risk reduction strategy.

Many types of threats exist, including confidentiality threats, integrity threats, and availability threats. Another threat is the malicious attack. These attacks can originate from active threats that include brute-force, masquerading, IP address spoofing, session hijacking, replay, man-in-the-middle, and dictionary password attacks. Passive threats can include eavesdropping and monitoring.

Vulnerabilities introduce weaknesses in the actual software used on production IT assets. Handling software vulnerabilities requires a vulnerability management plan that includes identifying and patching them in a timely manner. This race against time helps to reduce the vulnerability window and risk exposure caused by leaving exploitable vulnerabilities on production IT assets. With proper patching, this risk exposure can be reduced. Without it, hackers will likely find your software vulnerabilities and exploit them if they can.

Threat targets are increasing as more users and devices connect to the Internet. Black-hat, white-hat, and gray-hat hackers; script kiddies; and crackers can launch attacks against common targets, including computer systems, network components, software, electrical systems, and databases.

KEY CONCEPTS AND TERMS

Administrative control
Asset
Brute-force password attack
Corrective control
Countermeasure
Credential harvesting
Detective control
Deterrent control
Eavesdropping
Ethical hacker
Event
Exploit
Hacker
Hijacking
Impact
Incident
Intellectual property
Likelihood
Loss expectancy
Malicious attack
Man-in-the-middle attack
Opportunity cost
Phishing
Preventive control
Qualitative risk assessment
Quantitative risk assessment
Replay attack
Residual risk
Risk management
Safeguard
Sniffing
Social engineering

Spoofing
Technical control
Zero day

CHAPTER 3 ASSESSMENT

1. The main goal of a hacker is to circumvent access controls and potentially steal data.

   A. True

   B. False

2. Which of the following best describes intellectual property?

   A. The items a business has copyrighted

   B. Patents owned by a business

   C. Sales and marketing plans

   D. Customer lists

   E. All of the above

3. Which of the following terms best describes a person with very little hacking skills?

   A. Hacker

   B. Script kiddie

   C. Cracker

   D. Wannabe

   E. All of the above

4. A(n) _____ is a software tool that is used to capture packets from a network.

5. Which type of attack results in legitimate users not having access to a system resource?

   A. Denial

   B. Disclosure

   C. Alteration

   D. Spoofing

6. A qualitative risk assessment assigns a subjective risk rating to assess the risk.

   A. True

   B. False

7. Which of the following is an example of social engineering?

   A. SQL injection

   B. XML injection

   C. Security design

   D. Impersonation

   E. All of the above

8. Which of the following is an example of an administrative security control?

   A. Antivirus/anti-malware protection

   B. Data leakage prevention

   C. Standardized workstation and laptop images

   D. Security awareness training

   E. All of the above

9. Vulnerability assessment scanners look for software vulnerabilities in IP host devices.

   A. True

   B. False

10. Which of the following affects availability?

    A. Cross-site scripting

    B. SQL injection

    C. Denial

    D. Packet sniffing

    E. None of the above

11. Which type of attack involves capturing data packets from a network and transmitting them later to produce an unauthorized effect?

    A. Man in the middle

    B. Denial

    C. Replay

    D. Phishing

    E. SQL injection

12. The list of known software vulnerabilities maintained by MITRE is called:

    A. National Vulnerability Database (NVD)

    B. Common Vulnerabilities and Exposures (CVE)

    C. Zero-Day List (ZDL)

    D. Software Vulnerabilities List (SVL)

CHAPTER 4
Business Drivers of Information

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EVERY ORGANIZATION CARRIES OUT TASKS to satisfy business objectives, which leads to fulfilling organizational goals. Without goals, organizations have no purpose. You must identify the elements in an organization that support its business objectives.

These elements are the organization's **business drivers**, which include people, information, and conditions that support the business objectives. Information security activities directly support several common business drivers, including compliance and efforts to protect intellectual property. Security activities can also negatively affect business drivers, making it more difficult to satisfy the business objectives.

Several outside requirements, including legislation, regulation, industry demands, or even your own standards, direct how an organization carries out its tasks, and no organization is without some requirements with which it must comply. Most regulations require that plans be developed to handle business interruptions or disasters. In fact, most activities that restore operations after an interruption support several requirements.

Always consider different controls to satisfy compliance requirements. It is important that security activities be balanced with their impact on the business drivers to protect the security of information. In this chapter, you will learn about security-related business drivers and how they overall support business drivers.

Chapter 4 Topics

This chapter covers the following topics and concepts:

- Risk management's importance to organizational strategy

- How the business impact analysis (BIA), business continuity plan (BCP), and disaster recovery plan (DRP) differ from one another and how they are alike
- How to describe the impact of risks, threats, and vulnerabilities on an organization
- How to close the information security gap
- How to mitigate risk and achieve compliance with laws, regulations, and requirements
- How to protect individual private data
- How to mitigate the risk of mobile workers and use of personal devices

Chapter 4 Goals

When you complete this chapter, you will be able to:

- Position risk management and the way organizations should align risk management with organizational strategy
- Distinguish between BIA, BCP, and DRP and compare them
- Describe the impact of risks, threats, and vulnerabilities on the information technology (IT) infrastructure
- Define an acceptable level of risk or liability
- Shrink the information security gap based on risk-mitigation strategies
- Adhere to compliance laws and governance (i.e., policies, standards, procedures, and guidelines)
- Manage and mitigate risk as part of ongoing security operations
- Determine how to comply with confidentiality goals that are defined for the IT infrastructure
- Identify risks associated with mobile workers and use of personally owned devices

Risk Management's Importance to the Organization

Risk management is an organization's ongoing process of identifying, assessing, prioritizing, and addressing risks and is a core business driver necessary to ensure any organization's longevity. Any organization that does not have a good understanding of risks will stay in operation only until its luck runs out. Sooner or later, a risk will result in a material impact to an organization. If the organization has not prepared for such an event, it might not survive, whereas a good risk management program can help an organization weather the most disruptive realized negative risks and capitalize on realized positive risks.

Each part of the risk management process is separate but will likely occur multiple times. Risk management ensures that the risks that are most likely to have an effect on the organization have been planned for well in advance of events occurring. Every step toward a more secure environment, including risk management activities, should align with the organization's strategic goals. Otherwise, security may be perceived as being in conflict with those goals. Security controls that assist an organization in meeting objectives will be more easily accepted and respected. Thus, organizations that align security with their strategic business objectives can drive business success with risk mitigation.

Every business possesses assets or resources, whether intellectual property, infrastructure and facilities, or employees. Risk is the probability that an uncertain event will affect one or more of those resources. Even though most people view risks only in terms of negative effects, the **Project Management Body of Knowledge (PMBOK)**, a best practices guide for project management maintained by the **Project Management Institute (PMI)**, states that the effects of risk can be either positive or negative. PMI bases its risk management philosophy on a proactive approach, which simultaneously does the following:

- Minimizes the effects of negative risks

- Maximizes the effects of positive risks

Consider the classic relationship among risks, threats, and vulnerabilities, as shown in **FIGURE 4-1**.

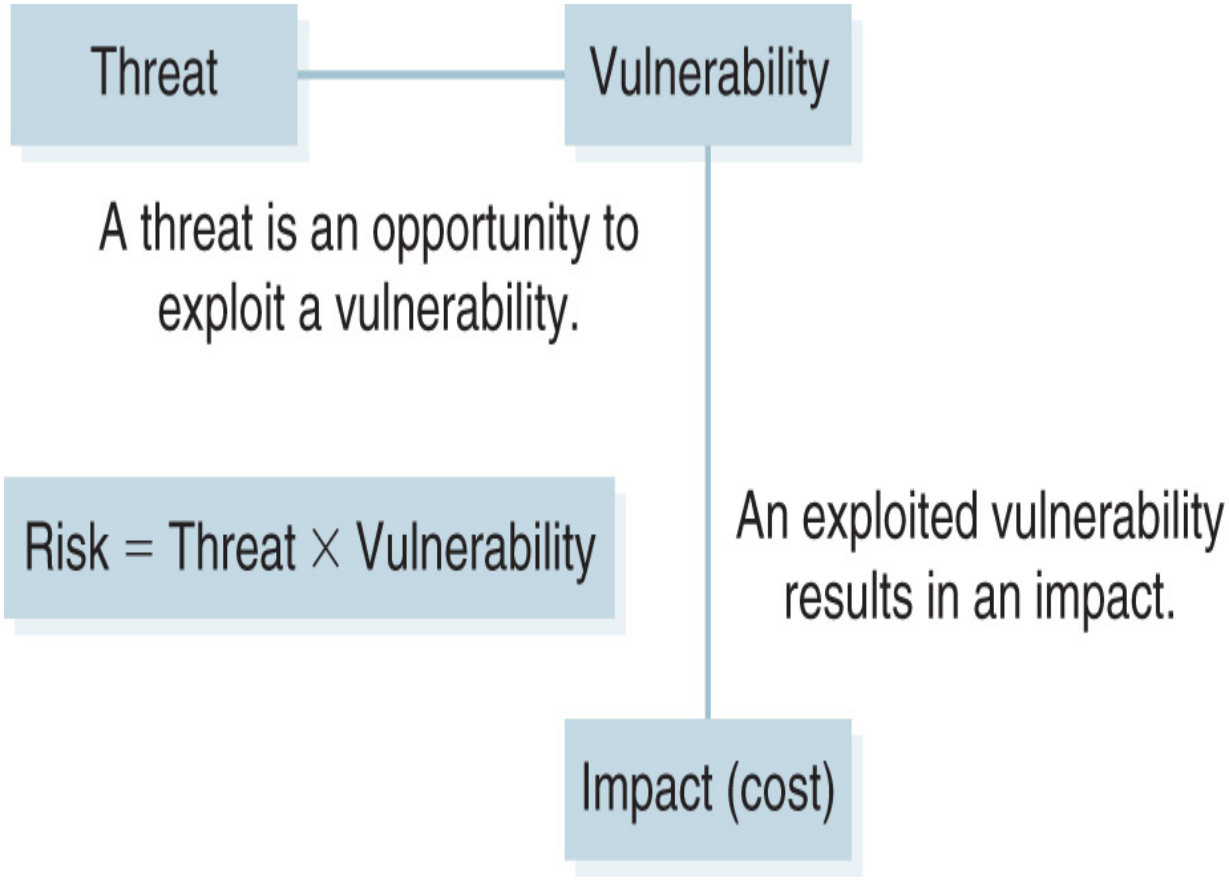

Threat
Vulnerability
A threat is an opportunity to exploit a vulnerability.
Risk = Threat × Vulnerability
An exploited vulnerability results in an impact.
Impact (cost)

FIGURE 4-1 Risks, threats, and vulnerabilities.

As shown in the figure, the risk equation is as follows:

$$\text{Risk} = \text{Threats} \times \text{Vulnerabilities}$$

We have already defined risk management terms at a conceptual level. To manage risk, it is also necessary to define several terms in the context of how they affect an organization. A *threat* is the frequency of any event. In most cases, the events in the threat equation are negative, or adverse, events. *Vulnerability* is the likelihood that a specific threat will successfully be carried out. Multiplying the probability of a threat and the likelihood of a vulnerability yields the *risk* of that particular event. Risks apply to specific

assets or resources. If you multiply the risk probability by the value of the resource, the result is the expected loss from exposure to a specific risk.

Many people have never thought of risk as a positive thing. However, uncertainty can result in events that have negative *or* positive effects. For example, suppose an organization plans to deploy new software to its end users, based on projected availability from its software vendor. The risk management plan should address the responses to both an early and a late software delivery. If the software is received early, either more exhaustive testing can be performed or early deployment begun. If the software vendor is late in delivering the software, the projected deployment date may be missed. Plans should be in place to address both the positive and negative effects of a delivery date that does not match the implementation schedule.

A common pitfall in building a risk management plan is to limit the scope of the risk identification process to just inside the organization. Today's organizations are interconnected and almost always rely on several third-party entities to conduct business. Unless everything a company needs in order to do business can be manufactured in-house, then the company must purchase some materials, supplies, and components from one or more outside vendors. A *vendor* is any business entity from which an organization purchases goods or services that it uses in its own operation. If purchased components or materials could contribute to the organization's risk, then it is important to evaluate how secure the vendors are. For example, suppose an organization produces Internet of Things (IoT) doorbells that include a camera purchased from another company. To ensure the product is secure, knowing whether that camera can operate securely with the doorbells is important.

However, vendors are not the only potential risks to organizations. The suppliers for the vendors may not be secure. In fact, any organization that participates in the process of creating and transporting goods, called a *supply chain*, may be a potential source of risk. To make matters even more complicated, business partners, which are other organizations that work with your organization to meet organizational goals, may expose your organization to risk. Your approach to risk management should include any third-party entities that could contribute to overall risk.

The main purpose of risk identification is to make the organization's personnel aware of existing risk, which does not address risks but does

provide the first step toward managing risk. There are two main classes of risks that the risk identification process should identify. **Inherent risk** is the risk as it currently exists, with any current controls in place. If a risk identification process determines that an organization's web server is vulnerable with the current firewall rules, that risk would be an inherent risk. *Residual risk* is the amount of risk that remains after adding more controls. It is difficult to eliminate all risk, so it is not unusual to still have some residual risk after implementing controls. Any additional controls should be implemented to reduce inherent risk to an acceptable level of residual risk.

A **risk methodology** is a description of how risk will be managed. The risk methodology that an organization adopts should include the approach, the required information, and the techniques to address each risk. The approach defines how the steps of the risk methodology process will be carried out. For example, the approach could state that risk analysis will be conducted at specified intervals. The tools for conducting this analysis can include the documents that define, categorize, and rank risks. This approach is consistent with the PMI's PMBOK. While the PMI approach is not the only way to do things, it does provide a prescriptive approach to project management in general, including risk management.

The result of the risk identification process is a list of identified risks. PMI calls this list the **risk register**. The risk register can contain many types of information but should contain at least the following:

- A description of the risk
- The expected impact if the associated event occurs
- The probability of the event's occurring
- Steps to mitigate the risk
- Steps to take should the event occur
- Rank of the risk

An organization's ability to respond to any risk starts with how well the organization identifies potential risks. Be creative when asking for risk register input. Using multiple perspectives will provide a more complete response plan. Input for the risk register can be solicited in several ways, including the following:

- Risk identification brainstorming meetings
- Formal surveys
- Informal polls and requests for comments
- Incentivized events, such as “lunch and learn” sessions, that include a forum for collecting comments and feedback

It is crucial to ensure that you have the support of your organization’s upper management from the very beginning in these risk identification activities because, without it, you will likely lack the authority to carry out the steps needed to develop a good risk management plan. Do not bring in management as an afterthought.

As the process of collecting information continues, more and more people should become involved. However, larger groups can discourage participants from speaking up about weaknesses within the organization. They may fear reprisal or that others will view them as complainers. You may find that one technique in particular, the Delphi method, produces the candid results you need. This is an approach to using formal, anonymous surveys in multiple rounds to collect opinions and information. Because the surveys are anonymous, the method encourages candid responses. A panel reviews each round of survey responses and creates a new survey based on the results of the previous round. Multiple rounds allow you to focus on areas of concern and assemble detailed information from a number of subject matter experts.

Now that you know what risk management is, it is important to consider how risks would apply to each of the seven domains of an IT infrastructure. This process starts with a risk, threat, and vulnerability assessment of the User, Workstation, LAN, LAN-to-WAN, WAN, Remote Access, and System/Application Domains.

Understanding the Relationship Between a BIA, a BCP, and a DRP

The primary focus of risk management is to preempt realized threats. It is not possible to foresee and prevent every event that could result in loss, meaning that the likelihood still exists that any organization will encounter an event that will interrupt normal business operations. Information security requires all information to be available when any authorized user needs it. Therefore, you will have to develop and implement methods and techniques for protecting the organization's IT resources and ensuring that events do not interrupt normal business functions.

Business Impact Analysis (BIA)

The first step in developing plans to address interruptions is to identify those business functions that are crucial to an organization because, when an event interrupts an organization's ability to conduct operations, it is important to restore those operations first. To identify those operations, a *business impact analysis* (BIA) is conducted.

A BIA is a formal analysis of an organization's functions and activities that classifies them as either critical or noncritical. It helps define a road map for business continuity and disaster recovery. Critical functions are required to run a business, whereas noncritical functions may be important but their absence would not stop an organization from conducting business. A BIA prioritizes critical activities based on importance and helps an organization determine which functions to restore in what order if there is a major interruption. BIAs also assist organizations with risk management and incident response planning.

In the BIA, each critical function is fully described in its own section, including a description of recovery goals and requirements for each function. Recovery goals and requirements are expressed as follows:

- **Recovery point objective (RPO)**—The **recovery point objective (RPO)** describes the target state of recovered data that allows an organization to continue normal processing. It is the maximum amount of data loss that is acceptable. Depending on the nature of the function, staff members may be able to re-create or reenter data. The RPO provides direction on how to back up data, what policies are needed regarding recovery, and whether loss prevention or loss correction is a better option.
- **Recovery time objective (RTO)**—The **recovery time objective (RTO)** expresses the maximum allowable time in which to recover the function. Many less formal recovery plans overlook the RTO. Time may be a critical factor, and specifying the requirements for recovery time helps determine the best recovery options.
- **Business recovery requirements**—These requirements identify any other business functions that must already be in place for the specified recovery function to occur and help in determining the recovery sequence.
- **Technical recovery requirements**—Technical recovery requirements define the technical prerequisites that are needed to support each critical business function. In most cases, technical recovery requirements dictate which IT infrastructure components must be in place.

Ensuring that operations and functions that are critical to an organization are able to continue is crucial to the organization's survival. The BIA will help identify which functions are critical, how quickly essential business functions must return to full operation following a major interruption, and resource requirements for returning each function to full operation. BIAs generally assume a worst-case scenario in which the physical infrastructure supporting each activity or function has been destroyed along with any data. Thus, the restoration plans assume that access to primary resources will not be possible for an extended period, at least 30 days, and will indicate the requirements necessary to conduct business when the normal infrastructure is unavailable.

Business Continuity Plan (BCP)

A BCP is a written plan for a structured response to any events that result in an interruption to critical business activities or functions. Performing a BIA is an important first step toward generating a BCP in that the BIA identifies the resources for which a BCP is necessary.

The BCP primarily addresses the processes, resources, equipment, and devices needed to continue conducting critical business activities when an interruption occurs that affects the business's viability. Therefore, generally, there is no reason to develop a BCP for resources that are not crucial to an organization's survival.

The most important part of any BCP is setting priorities, with the understanding that people *always* come first. Any plan that addresses business interruptions and disasters must place the safety and well-being of the organization's people as the highest priority, with all other concerns secondary. Thus, the order of priorities for a well-balanced BCP should be as follows:

- Safety and well-being of people
- Continuity of critical business functions and operations, whether onsite or offsite, manual, or dependent on IT systems
- Continuity of components within the seven domains of an IT infrastructure

You must address the needs of each category before continuing to the next category. If conditions are hazardous for people, people cannot be productive. If people are safe but the building is damaged, servers or network hardware cannot be replaced. If the building is damaged, the organization must be relocated before the damage to infrastructure components can be repaired and their function restored. Keep the order of resource priority in mind as you develop plans to avoid business process interruptions.

A formal BCP is not just helpful for many organizations; in some circumstances, it is required. Legislation and regulations often require a BCP to ensure that systems are safe. Today's organizations increasingly rely on IT resources and thus require a solid IT infrastructure to conduct business.

Direct and indirect costs for system downtime for these companies can be extreme and may exist in several categories as follows:

NOTE

Direct costs are immediate expenditures that reduce profit, whereas indirect costs, such as losing a customer, affect the overall revenue stream but are harder to calculate because there is no expenditure record. In the case of indirect costs, the impact is that potential sales just never happen.

- Lost customers
- Lost revenue
- Lost market share
- Additional expenses
- Damaged reputation

Organizations must consider contingency and recovery plans from a comprehensive perspective. Therefore, plans cannot focus on individual resources to the exclusion of others. Although each of the components of a contingency, or recovery, plan does generally address specific resources, it must do so within a larger context. Keeping the larger context in view during plan development enables you to address the risks to an organization as opposed to merely fixing a broken resource.

Elements of a complete BCP should include the following:

- Statement defining the policy, standards, procedures, and guidelines for deployment
- Project team members with defined roles, responsibilities, and accountabilities
- Emergency response procedures and protection of life, safety, and infrastructure

- Situation and damage assessment
- Resource salvage and recovery
- Alternate facilities or triage for short- or long-term emergency mode of operations and business recovery

Briefly, a BCP directs all activities required to ensure that an organization's critical business functions continue with little or no interruption and assumes that the infrastructure components needed to support operations are in place. Unfortunately, that is not always the case after a disaster. What happens when a fire destroys the data center? How can business operations continue in that case? The answer is, you need another plan, a disaster recovery plan.

Disaster Recovery Plan (DRP)

A DRP directs the actions necessary to recover resources after a disaster. It is part of a BCP and is necessary to ensure the restoration of resources required by the BCP to an available state. The DRP extends and supports the BCP by identifying events that could cause damage to resources that are necessary to support critical business functions, a list of which is already contained in the BCP. The next step, then, in developing a DRP is to consider what could happen to each resource.

BCP Versus DRP: What Is the Difference?

Unlike a DRP, a BCP does not specify how to recover from disasters but only from interruptions. In general, an *interruption* is a minor event that may disrupt one or more business processes for a short period. In contrast, a *disaster* is an event that affects several business processes for an extended period and often causes substantial resource damage that you must address before you can resolve the business process interruption.

Threat Analysis

A **threat analysis** involves identifying and documenting threats to critical resources, which means considering the types of disasters that are possible

and what kind of damage they can cause. For example, recovering from a data-center fire is different from recovering from a flu epidemic. Following are examples of common threats:

- Fire
- Flood
- Hurricane
- Tornado
- Pandemic or localized disease
- Earthquake
- Cyberattack
- Sabotage
- Utility outage
- Terrorism

With the exception of a pandemic, each of these threats has the potential to damage an organization's infrastructure. In contrast, a pandemic directly and indirectly affects personnel, which in turn affects business operations. Even if personnel avoid getting sick, they may be required to stay away from the physical workplace, which may create interruptions in business operations. Continuing business operations during a pandemic can be addressed with various solutions. If, however, the pandemic directly affects people charged with carrying out the recovery plans, the recovery may be unsuccessful.

Note that these threats do not necessarily occur one at a time. One threat may lead to another threat. For example, a flood that introduces contaminated water into an office may lead to disease that incapacitates staff. As another example, a tornado or earthquake could result in a fire. Always assume that disasters may occur in groups and not only as single events.

Impact Scenarios

After defining potential threats, the next step in creating a comprehensive DRP is to document likely impact scenarios, which form the basis of the DRP. In most organizations, planning for the most wide-reaching disaster, rather than focusing on smaller issues, results in a more comprehensive plan.

Narrowing the focus to smaller issues can result in a DRP that fails to consider a broader strategy, which is necessary to recover from the loss of multiple resources simultaneously. An impact scenario such as "Loss of Building" will likely encompass all critical business functions and the worst potential outcome from any given threat. If an organization has more than one building, a DRP may include additional impact scenarios.

Moreover, a solid DRP might also contain additional, more specific impact scenarios. For example, the plan may include a scenario that addresses the loss of a specific floor in a building or moving to another location. Moving from one location to another requires specific resources, which must be delineated in the DRP so that they are available when necessary to execute each step of the plan. A recovery plan that fails just because a truck large enough to move equipment to an alternate site was not available is not a very solid plan.

Recovery Requirement Documentation

Once the analysis phase has been completed, the business and technical requirements to initiate the implementation phase should be documented. This step will likely require access to asset information, including asset lists and their availability during a disaster. Each asset has an owner; therefore, the owner must grant the disaster relief team access to it. Typically, the BCP and DRP have team leaders who have full authority to conduct their tasks and functions to enable business continuity or recovery of business functions and operations. BCP and DRP teams typically include executive management, legal, and public relations staff members to address all aspects of internal and external communications.

The asset information, which includes the following, must already be identified and provided in the BCP and readily available for the disaster recovery team:

- Complete and accurate inventory of all facility assets
- Complete and accurate inventory of IT assets, hardware, software, licenses, contracts, and maintenance agreements
- Complete and accurate list of alternative office facilities and triage locations

- Complete and accurate list and contact details for business partners, vendors, service providers, and suppliers
- Work and personal contact information for disaster recovery team members
- Critical business functions and operations and required IT systems, applications, resources, and data recovery
- Retrieval of backed-up data for recovery and use
- Detailed IT system, application, and data recovery procedures
- Disaster recovery team members and resources needed for manual and workaround solutions
- RTOs and steps required to achieve them

Disaster Recovery

It is important to train all personnel on the proper response to any disaster. A common mistake is for personnel to be too eager to begin the recovery process. Even though the organization has devoted substantial time and resources to developing a DRP, be sure to react to the disaster and not to the plan. The critical steps in responding to a disaster include the following:

- **Ensure everyone's safety first**—No other resource is as important as people.
- **Respond to the disaster before pursuing recovery**—Required response and containment actions depend on the nature of the disaster and may not have anything to do with the recovery effort.
- **Follow the DRP, including communicating with all affected parties**—Once the people are safe and the disaster responded to, recovery actions can be pursued.

Disaster recovery is an extension of the DRP. It addresses recovering from common system outages or interruptions. A disaster is generally larger than a common outage, and the resources may not be available to enact simple recovery solutions. For example, most database management systems enable you to quickly recover the primary database from a replicated copy. However, if a disaster has resulted in the destruction of the database server

computer, you will have to restore the server to a stable state before you can restore the database data.

NOTE

In some industries, cooperative agreements are mandatory. For example, banks are required to maintain cooperative agreements with other banks as well as regularly test their ability to use other banks' facilities to ensure uninterrupted service to their customers.

A disaster may render the data center unusable, forcing operations to relocate. Careful planning for such a move makes it viable. Although moving a data center to another location may not sound like a major undertaking, it involves many details, which is why it requires so much effort to plan. Hardware and software must be installed, and there are network and telecommunications requirements. **TABLE 4-1** lists several common data-center options for disaster recovery.

TABLE 4-1 Data-center alternatives for disaster recovery.

OPTION	DESCRIPTION	COMMENTS
Hot site	Facility, with environmental utilities, hardware, software, and data, that closely mirrors the original data center	Most expensive option, least switchover time
Warm site	Facility with environmental utilities and basic computer hardware	Less expensive than a hot site but requires more time to load operating systems, software, data, and configurations
Cold site	Facility with basic environmental utilities but no infrastructure components	Least expensive option but at the cost of the longest switchover time because all hardware, software, and data must be loaded at the new site

OPTION	DESCRIPTION	COMMENTS
Mobile site	Trailer with necessary environmental utilities that can operate as a warm or cold site	Very flexible, fairly short switchover time, and widely varying costs based on size and capacity

NOTE

The options presented in **Table 4-1** refer to physical sites. With the growth of cloud computing, disaster recovery may be easier and less costly than providing alternate physical sites. Moving processing and data to a cloud environment assigns the risk of interruption to the cloud service provider, which is responsible for establishing backup processing and storage capability, as specified in the service-level agreement (SLA).

Working out a mutual aid agreement with another company whereby each organization agrees to provide backup resources in the event of a disaster may be advantageous. The agreement could include after-hours access to computing resources or physical space to use as a temporary data center. Carefully examine all the requirements when considering a cooperative agreement because, even though providing basic critical functionality for a data center may seem straightforward, some resources, such as telecommunications service, may not be easy to switch from one location to another. Also, consider how close any alternate location is to the existing location. If the proposed alternate location is too close to the main location, a large disaster, such as a flood or an earthquake, could affect both.

Disaster recovery is rapidly becoming an increasingly important aspect of enterprise computing. As business environments become more complex, more things can go wrong, which means that recovery plans have become more complex to keep up. DRPs vary from one organization to another, depending on many factors, some of which include the type of organization,

the processes involved, and the level of security needed. Most enterprises remain unprepared or underprepared for a disaster, and, despite recurrent reminders, many companies do not have a DRP at all. Of those that do, nearly half have never tested their plan, which is essentially the same as not having one.

It is crucial to validate the DRP for effectiveness and completeness and test it for accuracy. Rarely is the first version of a DRP complete and correct; therefore, testing the DRP to identify gaps is a must. Once the gaps have been identified, the DRP needs to be further refined. These tests can range from simple reviews to simulating real disasters, which includes transferring software between computer systems and ensuring that communications can be established at an alternate location. To assist in such tests, engage a disaster recovery firm. Following are various types of DRP tests:

- **Checklist test**—A checklist test is the simplest type of DRP test. In this test, each participant follows steps on the DRP checklist and provides feedback. Checklist tests can be used for DRP training and awareness.
- **Structured walk-through**—A structured walk-through, also called a *tabletop exercise* or a *conference room test*, is similar to a checklist test, but instead, the DRP team uses role-playing to simulate a disaster and evaluate the DRP's effectiveness.
- **Simulation test**—In a simulation test, which is more realistic than a structured walk-through, the DRP team uses role-playing and follows through with as many of the effects of a simulated disaster as possible without affecting live operations.
- **Parallel test**—A parallel test evaluates the effectiveness of the DRP by enabling full processing capability at an alternate data center without interrupting the primary data center.
- **Full-interruption test**—The only complete test is a full-interruption test, which interrupts the primary data center and transfer processing capability to an alternate site.

Not all aspects of DRPs are reactive; rather, some parts of a DRP are preventive and intended to avoid the negative effects of a disaster in the first place. Following are examples of preventive components of a DRP:

- Local mirroring of disk systems and use of data protection technology, such as a redundant array of independent disks (RAID) or storage area network (SAN) system
- Surge protectors to minimize the effect of power surges on delicate electronic equipment
- Uninterruptible power supply (UPS) and/or a backup generator to keep systems going in the event of a power failure
- Fire prevention systems
- Antivirus software and other security controls

Assessing Risks, Threats, and Vulnerabilities

One of the first steps in developing comprehensive BCPs and DRPs is to fully assess the risks, threats, and vulnerabilities associated with an organization's critical resources. Because no environment can be protected from every possible threat, it is necessary to prioritize, which means that until you know the risks, you cannot know which remedies are necessary.

There are many approaches to assessing risk, and each organization conducts the process in its own unique way. Instead of starting from scratch in the risk assessment process, you can use one of the many methodologies that are available. At least one of these methods is likely a good fit for the organization. Investing the time to research the various offerings can make the whole process more effective and efficient. **TABLE 4-2** lists common risk assessment methodologies.

TABLE 4-2 Common risk assessment methodologies.

NAME	DESCRIPTION	FOR MORE INFORMATION
Risk Management Guide for Information Technology Systems **(NIST SP800-30)**	Part of the Special Publication 800 series reports, these products provide detailed guidance on what should be considered in risk management and assessment in computer security. The reports include checklists, graphics, formulas, and references to U.S. regulatory issues.	*http://csrc.nist.gov*
Operationally Critical Threat, Asset, and Vulnerability Evaluation (OCTAVE)	The OCTAVE approach defines a risk-based strategic assessment and planning technique for security and is a self-directed approach. There are two versions of the OCTAVE: OCTAVE FORTE and OCTAVE Allegro. OCTAVE FORTE is best suited for large organizations, whereas OCTAVE Allegro works well for organizations consisting of fewer than 100 people.	*https://resources.sei.cmu.edu/library/asset-view.cfm?assetid=644636*

NAME	DESCRIPTION	FOR MORE INFORMATION
ISO/IEC 27005:2018 "Information Security Risk Management"	An ISO standard that describes information security risk management in a generic manner. The documents include examples of approaches to information security risk assessment and lists of possible threats, vulnerabilities, and security controls.	*www.iso.org*

Closing the Information Security Gap

Despite best efforts, no collection of security controls is perfect, and there are always some vulnerabilities for which there are no controls. The difference between the security controls that are in place, as outlined in the **security policy** (i.e., defines risk-mitigating solutions for an organization), and the controls that are necessary to address all vulnerabilities is called the **security gap**, which is determined by conducting a **gap analysis**.

Gap analysis activities should be ongoing and should consist of regular reviews of day-to-day practices vis-à-vis the latest threat assessment. Threats that you do not address through at least one control indicate gaps in the security.

Performing gap analysis is an effective method for gauging the overall security of an organization's IT environment as well as providing assurances that security implementations are consistent with real requirements. You can conduct many different types of gap analysis activities, ranging from formal investigations to informal surveys. Factors that influence the analysis include the size of the organization, the industry in which it operates, the cost and efforts involved, and the depth of the analysis. Gap analysis often includes many of the following steps:

- Identifying the applicable elements of the security policy and other standards
- Assembling policy, standard, procedure, and guideline documents
- Reviewing and assessing the implementation of the policies, standards, procedures, and guidelines
- Collecting inventory information for all hardware and software components
- Interviewing users to assess knowledge of and compliance with policies
- Comparing the current security environment to policies in place
- Prioritizing identified gaps for resolution
- Documenting and implementing the remedies to conform to policies

One important aspect of a gap analysis is determining the cause of the gap. The fact that a gap exists means there is a lack of adequate security controls, but *why* does the gap exist? There are several common reasons for security gaps in any organization, such as the following:

- Lack of security training, resulting in noncompliant behavior
- Intentional or negligent disregard of security policy
- Unintended consequence of a control or policy change
- Addition or modification of hardware or software without proper risk analysis
- Configuration changes that lack proper risk analysis
- Changes to external requirements, such as legislation, regulation, or industry standards, that require control changes

From this list, it is evident that most security gaps relate closely to user actions. One of the first steps you can take to close gaps is to ensure that personnel are fully trained on security issues because well-trained people are the best allies in securing an IT environment. As your security efforts become more sophisticated and the organization's personnel become more security savvy, you should encounter fewer security gaps.

Adhering to Compliance Laws

The past three to four decades have seen an explosion in computing power and in the number of ways computers are used. The increased reliance on networked resources, hardware, and software has created many new opportunities for the malicious use of resources. Information has become a valued asset to organizations and an attractive target of attackers. As information-related crime has grown, so has legislation and regulation to protect organizations and individuals from criminal activity.

Today's organizations are increasingly subject to various laws enacted to protect the privacy of electronic information. Each organization must comply with laws and regulations, although the specific laws and regulations to which an organization is subject depend on the organization's location, the type of information it handles, and the industry in which it operates.

The following list summarizes many of the most far-reaching laws and regulations that affect how organizations conduct IT operations:

- **Family Education Rights and Privacy Act (FERPA)**—Passed in 1974, this federal law was an early measure to protect the privacy of student education records. It applies to all schools that receive funds under an applicable program of the U.S. Department of Education. Under FERPA, schools must receive written permission from a parent or an eligible student before releasing any information contained in a student's education record.
- **Federal Financial Institutions Examination Council (FFIEC)**—The FFIEC was initiated in 1979 to establish a standard for security controls and maturity assessments, which include an inherent risk profile assessment and a cybersecurity maturity assessment. Using these two benchmarks, financial organizations can assess their current risk profile and their current cybersecurity maturity level based on performing these self-assessments internal to their organization.
- **Children's Online Privacy Protection Act of 1998 (COPPA)**—COPPA restricts how online information is collected from children under 13 years of age. COPPA was made effective in 2000 and gained

additional consent requirements in 2013. It dictates what a website operator must include in a privacy policy, when and how to seek verifiable consent from a parent, and what responsibilities an operator has to protect children's privacy and safety online.

- **Gramm-Leach-Bliley Act (GLBA)**—GLBA, passed in 1999, addresses information security concerns in the financial industry. GLBA requires that financial institutions provide their clients a privacy notice that explains what information the company gathers about the client, where the information is shared, and how the company protects that information. Companies must provide clients with this privacy notice before they enter into an agreement to do business.
- **Government Information Security Reform Act (Security Reform Act) of 2000**—This act focuses on management and evaluation of the security of unclassified and national security systems. It formalized existing Office of Management and Budget security policies and restated security responsibilities contained in the Computer Security Act of 1987.
- **The USA PATRIOT Act of 2001**—Passed 45 days after the September 11, 2001, attacks on the World Trade Center in New York City and on the Pentagon in Washington, DC, the PATRIOT Act substantially expanded the authority of U.S. law enforcement agencies to enable them to fight terrorism in the United States and abroad. It expands the ability of law enforcement agencies to access information that pertains to an ongoing investigation.
- **Federal Information Security Management Act (FISMA)**—FISMA officially recognizes the importance of information security to the national security and economic health of the United States. FISMA was enacted in 2002 and required every federal agency to develop and maintain formal information security programs, including security awareness efforts; secure access to computer resources; strict **acceptable use policies (AUPs)**; and formal incident response and contingency planning.
- **Sarbanes-Oxley Act (SOX)**—Sarbanes-Oxley, which became law in July 2002, introduced sweeping changes to the way corporate governance and financial practices are regulated. As a direct result of several public financial scandals, SOX established the Public Company

Accounting Oversight Board (PCAOB), which is responsible for overseeing, regulating, inspecting, and disciplining accounting firms in their roles as auditors of public companies. SOX also dictates policies that address auditor independence, corporate governance, internal control assessment, and enhanced financial disclosure.

- **California Security Breach Information Act (SB 1386) of 2003**—This act, along with several other similar state acts, requires any company that stores customer data electronically to notify its customers any time there is a security breach. The company must immediately notify any affected customers if someone breaches its computer system and steals unencrypted information. Other similar bills limit the ability of financial institutions to share nonpublic personal client information with affiliates and third parties.
- **Health Insurance Portability and Accountability Act (HIPAA)**—HIPAA, which took effect on April 14, 2006, governs the way doctors, hospitals, and other health care providers handle personal medical information. HIPAA requires that all medical records, billing, and patient information be handled in ways that maintain the patient's privacy. HIPAA also guarantees that all patients be able to access their own medical records, correct errors or omissions, and be informed of how personal information is used. To ensure every affected person is aware of HIPAA's requirements, patients must receive notifications of privacy procedures any time they submit medical information.
- **Federal Information Security Modernization Act (FISMA)**—FISMA 2014 is the update to the original FISMA enacted in 2002. This is the first amendment to the original FISMA. Updates to FISMA 2014 include the following:
    - Reasserts the authority of the director of the Office of Management and Budget (OMB) with oversight while authorizing the Secretary of the Department of Homeland Security (DHS) to administer the implementation of security policies and practices for federal information systems
    - Requires agencies to notify Congress of major security incidents within seven days. OMB will be responsible for developing guidance on what constitutes a major incident.

    - Places more responsibility on agencies looking at budgetary planning for security management, ensuring that senior officials accomplish information security tasks and that all personnel are responsible for complying with agency information security programs
    - Changes the reporting guidance focusing on threats, vulnerabilities, incidents, the compliance status of systems at the time of major incidents, and data on incidents involving personally identifiable information (PII)
    - Calls for the revision of OMB Circular A-130 to eliminate inefficient or wasteful reporting
    - Provides for the use of automated tools in agencies' information security programs, including periodic risk assessments; testing of security procedures; and detecting, reporting, and responding to security incidents
- **European Union (EU) General Data Protection Regulation (GDPR) of 2016**—The EU GDPR is the world's most comprehensive law on personal data and privacy protection. The GDPR not only covers how data on EU citizens is collected, stored, and used, but also governs data that flows into or out of the EU. GDPR's focus is to give control of private data back to the individual. Organizations that handle any private data must inform data owners how their data will be handled and request specific authorization to collect and use it. Individuals are also authorized to demand that their personal data be deleted on demand.
- **Payment Card Industry Data Security Standard (PCI DSS v3.2.1)**—Although not a law, PCI DSS v3.2.1, released in 2018 as the latest update to this 2004 industry standard, affects any organization that processes or stores credit card information. The founding payment brands of the PCI Security Standards Council—American Express, Discover Financial Services, JCB, MasterCard Worldwide, and Visa International—developed PCI DSS v3.2.1 to foster consistent global data security measures. The PCI DSS v3.2.1 is a comprehensive security standard that includes requirements for security management, policies, procedures, network architecture, software design, and other critical protective measures.

- **California Consumer Privacy Act (CCPA) of 2018**—The CCPA is similar in many ways to the GDPR and is also called "GDPR lite." Like the GDPR, the CCPA focuses on individual privacy and rights of data owners. This strong privacy law covers all California consumers and impacts any organizations that interact with them.

NOTE

A **privacy policy** defines what an organization does with the data it collects about a person and why it collects that data. Privacy policies also explain what persons must do if they do not want their data to be shared or sold to third parties.

FIGURE 4-2 shows a timeline of important security compliance laws and standards.

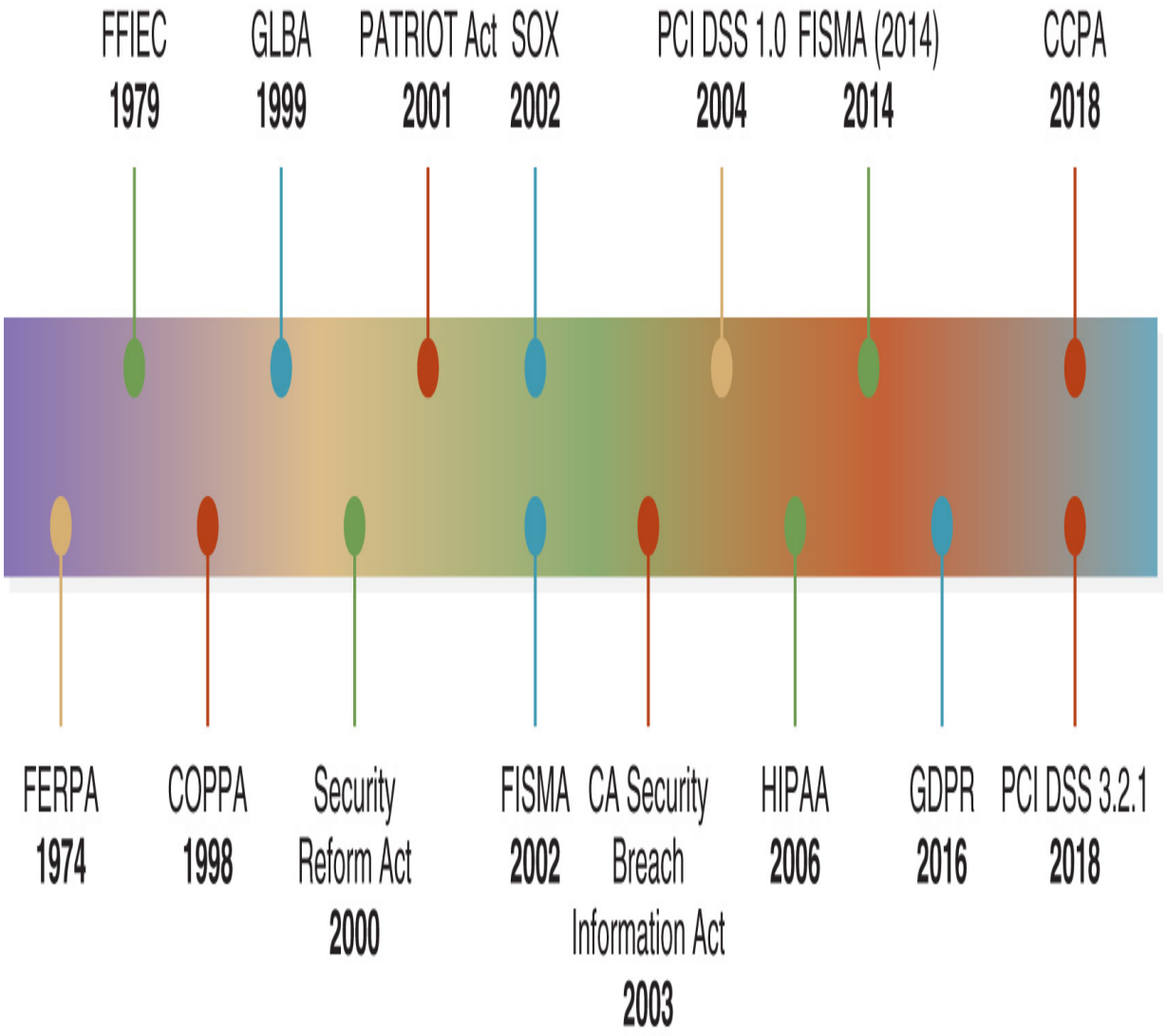


FIGURE 4-2 Security compliance laws and standards timeline.

Each organization bears the responsibility of understanding which laws and regulations apply to it and to employ necessary controls to comply. This compliance effort often requires frequent attention and results in audits and assessments to ensure that the organization remains compliant.

Keeping Private Data Confidential

Many of the compliance requirements that we presented in earlier sections address data confidentiality. Even though ensuring availability and integrity of data is important, keeping private information confidential garners the most attention because, once the confidentiality of data has been breached, it cannot be undone. In other words, once people view confidential data, there is no way to remove that data from their memory. Careful attention must be paid to each of the three tenets of information security, as shown in **FIGURE 4-3**, to protect an organization's data assets.

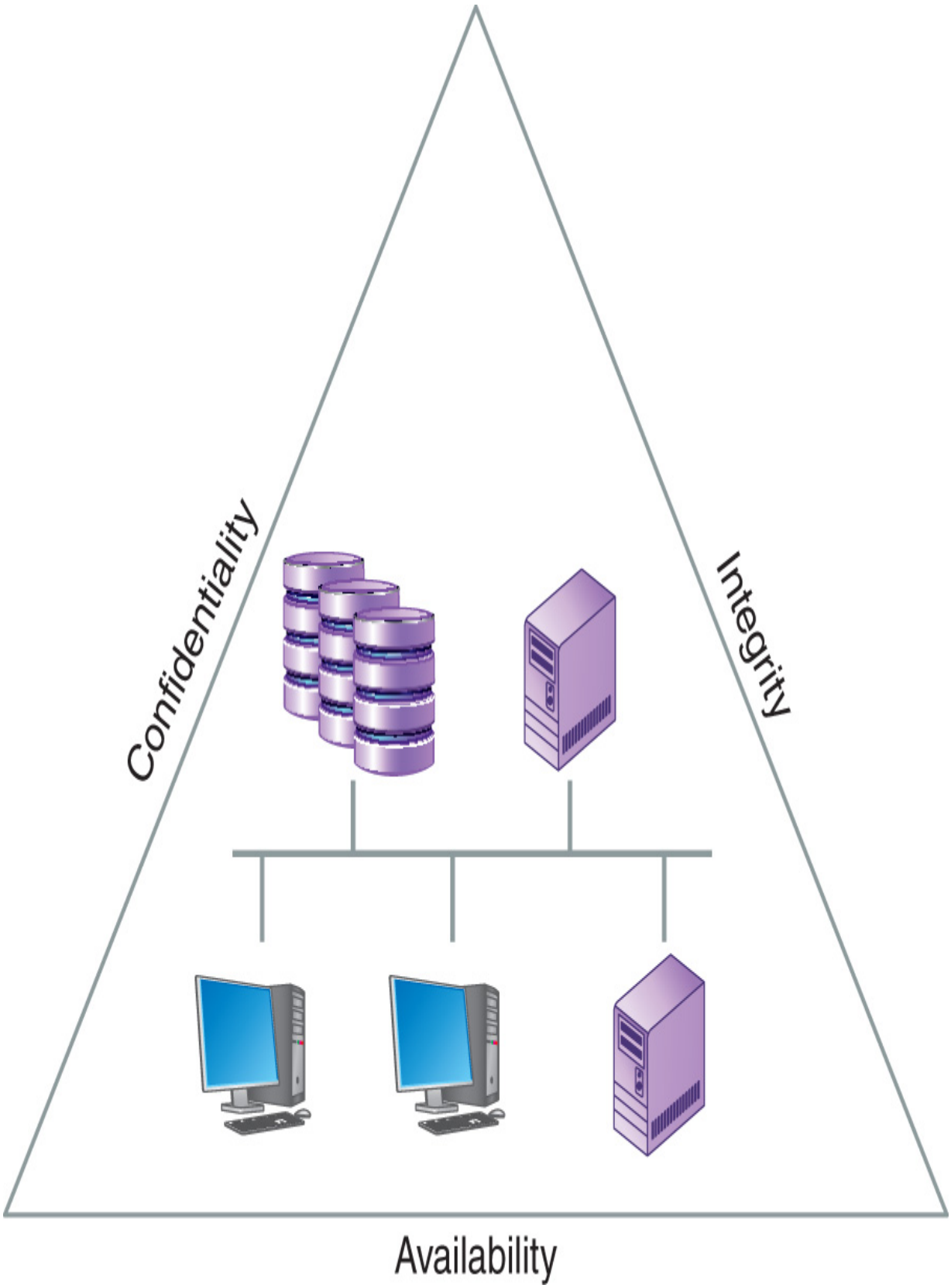


FIGURE 4-3 The three tenets of information security.

There are various techniques to ensure the confidentiality, integrity, and availability of data. At the highest level, data is secure when it is available only to authorized users. Many details will need to be covered before the security of an organization's data can be fully ensured. Maintaining confidentiality will certainly be a recurring theme. In fact, many controls to ensure confidentiality also ensure other aspects of data security.

NOTE

In the context of monitoring information system activity, the term **accounting** means recording events in log files. You can use computer event accounting to trace users' actions and determine a sequence of events that is helpful with investigating incidents.

As you learn more about various security controls, you will see how they work together to protect data from unauthorized use. Most strategies to secure data use a three-pronged approach that includes the techniques of authentication, authorization, and accounting. These three techniques help ensure that only authorized users can access resources and data. They also ensure that enough information is captured to troubleshoot access issues after the access occurs. Investigations into security incidents rely on accounting information to reconstruct past events.

The basic purpose of the three-pronged approach is to maintain security by preventing unauthorized use of any protected resource. Many authentication and access controls can help accomplish this task. Some of the authentication controls you will learn about include the following:

- Passwords and personal identification numbers (PINs)
- Smart cards and tokens
- Biometric devices
- Digital certificates
- Challenge-response handshakes

- Kerberos authentication
- One-time passwords

NOTE

Businesses and organizations under a regulatory compliance law must address regulated data versus nonregulated data. Data that is under a regulatory compliance requirement typically means that that data must have incorporated proper security controls, including stringent access controls, real-time monitoring, and data encryption at rest, in storage, and in transit. Data confidentiality is a top-of-mind business challenge for organizations under a regulatory compliance law. Proper data confidentiality security controls can mitigate the threat of a data breach or loss. Any organization not employing proper controls to comply with regulations might be subject to fines levied against them or even to criminal prosecution.

Once a user has been authenticated, access controls help ensure that only authorized users can access the protected resource. Authorization controls you will learn about include the following:

- Authentication server rules and permissions
- Access control lists
- Intrusion detection and prevention
- Physical access control
- Connection and access policy filters
- Network traffic filters

These two lists give a brief overview of some of the security controls that help to ensure an organization’s data security.

Mobile Workers and Use of Personally Owned Devices

Another emerging business driver for companies and organizations is **mobility**, which allows remote workers and employees to be connected to the IT infrastructure in almost real time. Mobility means that speed and effective communications can help businesses increase productivity, sales, revenue, and profit. The hyperconnected mobile worker is now "always on," which helps drive productivity throughout the organization. The prevalence of these mobile road warriors, such as outside sales representatives who visit clients, introduces a critical risk element for businesses given that the point of entry into the organization's IT infrastructure is performed by the users within the User Domain connecting via the Workstation Domain with their endpoint devices. Depending on the given situation, the endpoint device can be anything from a laptop or tablet to a smartphone, and each of these devices introduces its own risks, threats, and vulnerabilities. Mobility is the business driver that is leading businesses and organizations to adopt a Bring Your Own Device (BYOD) strategy. BYOD is a term that addresses employees using their personally owned devices, such as a laptop computer or smartphone, for business, as well as personal, use.

BYOD Concerns

The acceptance of a BYOD policy into corporate and government environments has created a unique business challenge that is based on the fact that the IT asset is owned by the employee. Regardless, that IT asset and its user still must abide by the organization's mobility policy, BYOD policy, and AUP. The following elements are commonly addressed in a BYOD policy definition:

NOTE

Businesses and organizations must decide whether to allow the use of personal IT assets for business purposes, which includes employees using personal smartphones for business emails that may or may not contain sensitive data as an email attachment. Mobility is driving the convergence of business and personal-use IT assets, and the use of social media is driving the convergence of business and personal communications and information sharing. The investment needed to provide laptops and smartphones for employees may be cost prohibitive for some businesses or organizations. Thus, many organizations are now implementing policies and procedures to ensure the confidentiality of business information on personally owned devices, such as laptops or smartphones. Employees using personal IT assets typically must still abide by the organization's AUP; email and Internet usage policy; and BYOD policy, which may require authorization to perform data wiping or data deletion in the event of loss or theft of the device.

- **Data ownership**—Personal data, such as contacts, pictures, or emails, is the intellectual property of the employee, whereas business emails and all attachments are the intellectual property of the organization. This distinction must be clearly defined in a BYOD policy.
- **Support ownership**—The employee owns the IT asset and all support and maintenance responsibilities unless reimbursement is approved by the organization.
- **Patch management**—Software updates and patches are recommended and should be performed by the employees on their own devices, as defined by the organization through policy definition.
- **Antivirus management**—Any IT asset that accesses the organization's intellectual property must have proper (as defined by the BYOD policy) antivirus/anti-malware protection installed.
- **Forensics**—Employees must agree that, if their personally owned IT asset is part of a formal incident response investigation, it may be confiscated to conduct a thorough forensics investigation on it.
- **Privacy**—Employees are entitled to retain and maintain their privacy; however, the organization's AUP and definitions for data wiping and

data deletion must be fully understood by employees before they agree to use their personally owned devices to conduct business.

- **Onboarding/offboarding**—The BYOD policy should be explained and agreed to during the onboarding process conducted by human resources. The policy should include handling (e.g., data wiping and data deletion) of the personally owned IT asset during offboarding prior to employee termination and removal of access controls.
- **Adherence to corporate policies**—The use of personally owned IT assets requires employees to abide by all other policies and procedures, including the AUP.
- **User acceptance**—The employee must agree to data wiping and data deletion (as required by the BYOD policy) in addition to a separation of private data versus business data.
- **Architecture/infrastructure considerations**—The use of any personally owned IT asset must meet the organization's IT standards and may require installation of new software to assist with security.
- **Legal concerns**—Employees must agree to abide by the organization's policies and procedures, particularly if a legal issue or incident investigation is involved (e.g., a forensics investigation).
- **Acceptable use policy**—Employees must abide by all organizational policies and procedures, in particular the organization's AUP.
- **Onboard camera/video**—The BYOD policy should address the use of camera and video capabilities of any personally owned IT asset. The content of those pictures and videos must abide by the AUP. Typically, employees are responsible for all personal data backups, including pictures and videos.

Some of the concerns around employees having their own devices are eliminated when an organization takes a more controlling or active role in personal device management. For example, an approach called Choose Your Own Device (CYOD) means the company might opt to provide employees with a few options from which to choose a device, for example, a device from each mobile operating system or vendor might be offered. Fewer options allow for easier device management, though the employee is still free to use the device as freely as in the BYOD model. Organizations wanting to

further reduce risk and permit full management might instead prefer company-owned and -controlled devices, such as company-owned/personally enabled (COPE) devices or company-owned business-only (COBO) devices. COPE is a benefit to employees wanting only one device, whereas COBO means the company device is for company business only.

While BYOD is the common term, the real way organizations handle employees' use of mobile devices is not as "hands off" as BYOD suggests. It more often falls somewhere within the spectrum of company-managed or company-owned devices, guided by policies, agents, and who pays the bills.

Endpoint and Device Security

With mobility and BYOD policies comes the need to enable endpoint or device security controls. The following discussion presents endpoint device security controls that can mitigate the risks, threats, and vulnerabilities commonly associated with mobility and BYOD environments:

- **Full device encryption**—Require that laptops, tablets, and smartphones be equipped with data encryption, thus mitigating the risk of a lost or stolen device.
- **Remote wiping**—Install software that will enable organizations to initiate remote wiping of data or email in the event of loss or theft of the device.
- **Lockout**—Require device screen savers with lockout timers that conform to the organization's Workstation Domain security policies and procedures.
- **Screen locks**—Require a password-protected screen-lock function that requires the owner to enter a password to gain access to the device.
- **Global positioning system (GPS)**—Install a GPS that uses satellite and/or cellular communications to pinpoint the physical location of the device if it is connected to a communications network.
- **Application control**—Install software that allows for application or device control.

- **Storage segmentation**—Require that devices that are shared for personal and business use have segmented storage to physically separate personal data from business data.
- **Asset tracking**—Require that all IT assets that are connected to the IT infrastructure, whether personally owned or owned by the organization, be tracked as IT assets by the organization.
- **Inventory control**—Require that all mobile devices owned by employees be IT–asset inventoried such that proper change management and incident response can be performed to all endpoint devices.
- **Mobile device management**—Require that a mobile device management (MDM) software agent (a software application that allows organizations to monitor, control, data wipe, or data delete business data from a personally owned device) be installed on all mobile devices.
- **Device access control**—Require that all personally owned devices conform to the organization's BYOD policy and have proper device access controls to access the IT asset itself, access controls for email access, and access controls for remote access to the IT infrastructure.
- **Removable storage**—Require the use of removable storage or data backups as defined in the organization's BYOD policy and AUP. Data backups of personal data are the responsibility of the employee, and data backups of business data are the responsibility of either the employee or the organization, according to policy definition.
- **Disabling unused features**—Depending on the BYOD policy and AUP definition, disallow the use of specific applications and features, such as the use of text messaging of sensitive data.

CHAPTER SUMMARY

In this chapter, you learned that security is much more than a way to keep data secret; it is an integral business driver for any organization. BCP and DRP readiness ensures that an organization can perform its primary business functions, even in the event of a disaster, and that it will do so by protecting all of its assets, including its data. A sound security infrastructure provides the assurance that the organization has employed the necessary controls to comply with all necessary laws, regulations, and other security requirements. In short, security keeps an organization viable and allows it to conduct business.

Moreover, this chapter presented business drivers for information systems security. Regardless of the type of business or vertical industry, compliance, security, and privacy are driving requirements for implementing proper security controls. Confidentiality of regulated data is a top-of-mind business driver. Mobility and the use of personally owned IT assets are also driving the way organizations permit the use of BYOD assets for their personnel.

KEY CONCEPTS AND TERMS

Acceptable use policy (AUP)
Accounting
Business driver
Gap analysis
Inherent risk
Mobility
Privacy policy
Project Management Body of Knowledge (PMBOK)
Project Management Institute (PMI)
Recovery point objective (RPO)
Recovery time objective (RTO)
Risk methodology
Risk register
Security gap
Security policy
Threat analysis

CHAPTER 4 ASSESSMENT

1. Risk management focuses on responding to a negative event when it occurs.

   A. True

   B. False

2. With respect to IT security, a risk can result in either a positive or a negative effect.

   A. True

   B. False

3. According to PMI, which term describes the list of identified risks?

   A. Risk checklist

   B. Risk register

   C. Risk methodology

   D. Mitigation list

   E. All of the above

4. What is the primary purpose of a business impact analysis (BIA)?

   A. To identify, categorize, and prioritize mission-critical business functions

   B. To provide a road map for business continuity and disaster recovery planning

   C. To assist organizations with risk management

   D. To assist organizations with incident response planning

   E. All of the above

5. Which of the following terms defines the maximum allowable time it takes to recover a production IT system, application, and access to data?

   A. Recovery point objective

B. Recovery time objective

C. Risk exposure time

D. Production recovery time

E. None of the above

6. The recovery point objective (RPO) defines the state at which _____ processing is able to resume.

A. Recovery

B. Alternate site

C. Limited

D. Normal

7. Which of the following solutions are used for authenticating a user to gain access to systems, applications, and data?

A. Passwords and PINs

B. Smart cards and tokens

C. Biometric devices

D. Digital certificates

E. All of the above

8. Which risk management approach requires a distributed approach with business units working with the IT organization?

A. OCTAVE

B. CRAMM

C. NIST SP800-30

D. ISO 27005

E. None of the above

9. The NIST SP800-30 standard is a _____management framework standard for performing risk management.

A. Risk

B. Threat

C. Vulnerability

D. Security

E. None of the above

10. Which term indicates the maximum amount of data loss over a time period?

A. RAI

B. ROI

C. RTO

D. RPO

E. None of the above

11. Organizations that permit their employees to use their own laptops or smartphone devices and connect to the IT infrastructure describe a policy referred to as:

A. RTO

B. MDM

C. BYOD

D. AUP

E. None of the above

12. Which of the following are organizational concerns for BYOD and mobility?

A. Data ownership

B. Privacy

C. Lost or stolen device

D. Data wiping

E. All of the above

13. _____ is the U.S. security-related act that governs regulated health care information.

14. Which U.S. security-related act governs the security of data specifically for the financial industry?

A. GLBA

B. COPPA

C. HIPAA

D. FERPA

E. None of the above

15. Which of the following business drivers are impacting businesses' and organizations' security requirements and implementations?

A. Mobility

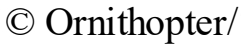
B. Regulatory compliance

C. Productivity enhancements

D. Always-on connectivity

E. All of the above

PART II
Securing Today's Information Systems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CHAPTER 5 Networks and Telecommunications
CHAPTER 6 Access Controls
CHAPTER 7 Cryptography
CHAPTER 8 Malicious Software and Attack Vectors
CHAPTER 9 Security Operations and Administration
CHAPTER 10 Auditing, Testing, and Monitoring
CHAPTER 11 Contingency Planning
CHAPTER 12 Digital Forensics

CHAPTER 5
Networks and Telecommunications

SOCIETY TODAY RELIES on networks and telecommunications to support interaction and business transactions. The hardware components and software that provide these communications functions are critical parts of business infrastructure, and many organizations could not operate if their networks were unavailable or became unreliable. With the expansion of cloud-based and distributed services in enterprise operations, networks have become integral parts of critical infrastructure. Network security involves meeting an organization's fundamental need for network availability, integrity, and confidentiality. To satisfy this multifaceted need, data transmitted through the network must be protected from modification (either accidental or intentional) and encrypted so it cannot be read by unauthorized parties, and all network traffic sources and destinations must be verified (i.e., nonrepudiation). Secure networks must fulfill five basic requirements:

- Access control
- Network stability and reliability
- Integrity
- Availability
- Confidentiality, or nonrepudiation

This chapter examines how you can secure network infrastructures and telecommunications. Moreover, it introduces the basic elements of a network, explains the security issues surrounding networks, and presents some of the building blocks for securing both the data that travels throughout the network and the services the network infrastructure supports.

Chapter 5 Topics

This chapter covers the following topics and concepts:

- What the Open Systems Interconnection (OSI) Reference Model is
- What the main types of networks are
- What Transmission Control Protocol/Internet Protocol (TCP/IP) is and how it works
- What network security risks are
- How to identify and implement basic network security defense tools
- How wireless networks work and what threats they pose to network security

Chapter 5 Goals

When you complete this chapter, you will be able to:

- Describe the OSI Reference Model
- Understand network types, protocols, and security risks
- Choose basic tools to defend against network security risks
- Understand wireless networking and the threats it can pose to network security

The Open Systems Interconnection Reference Model

The **Open Systems Interconnection (OSI) Reference Model** is a theoretical model of networking with interchangeable stacked layers that can be used as a template for documenting, building, and using a network and its connected resources. The beauty of it is that you can design technology for any one of the layers without worrying about how the other layers work. You merely need to make sure that each layer knows how to talk to the layers above and below it. The OSI Reference Model defines a stack of layers, starting from the Physical Layer, at the bottom, which interacts with the physical hardware of the network infrastructure. **FIGURE 5-1** shows each layer of the OSI Reference Model.

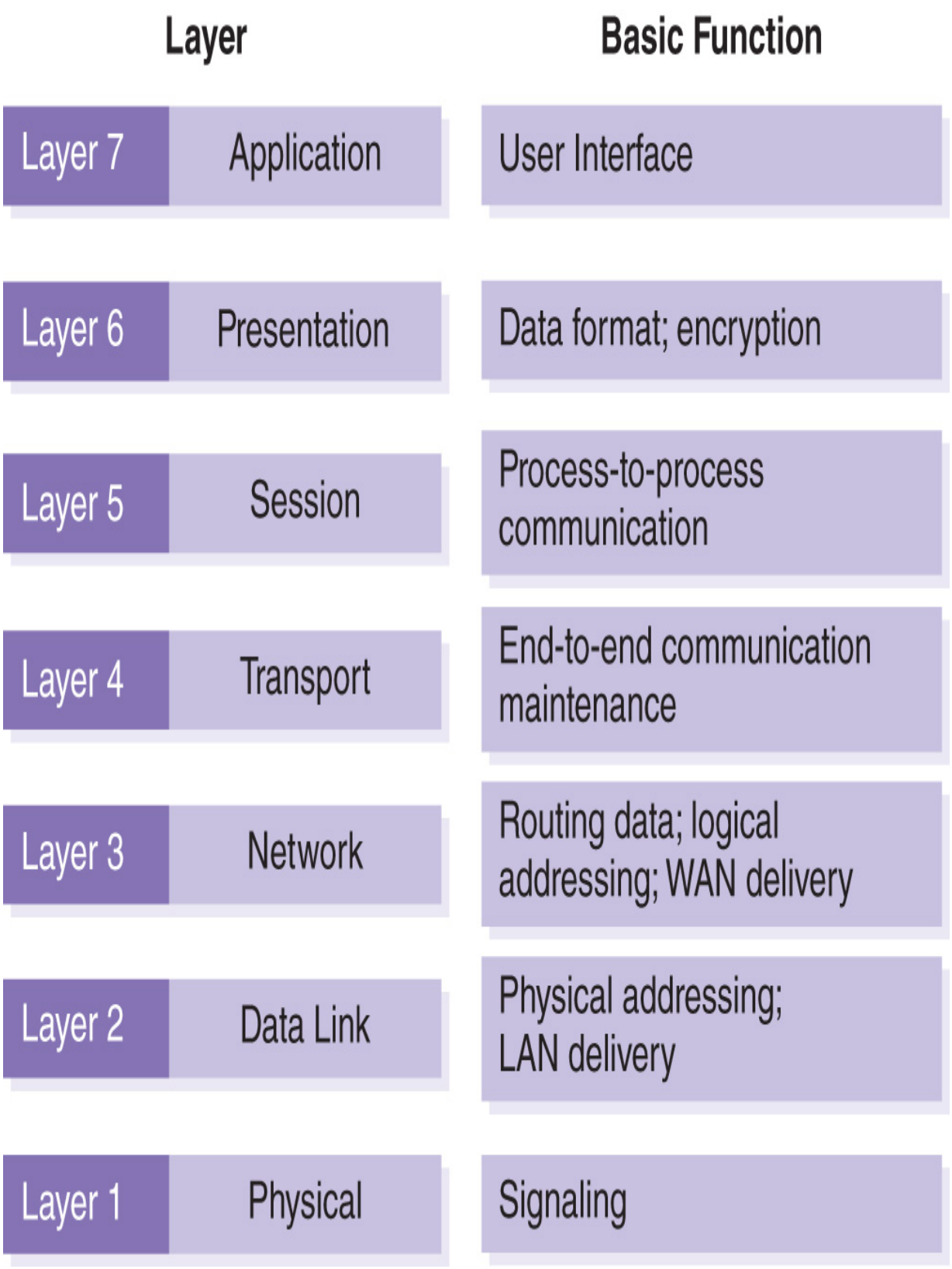


FIGURE 5-1 The OSI Reference Model.

Following are the individual layers of the OSI Reference Model (starting from the top of the stack):

- **Application Layer (Layer 7)**—This layer is responsible for interacting with end users through application software and thus includes all programs on a computer that allow users to interact with the network. For example, email software is included in this layer because it must transmit and receive messages over the network, whereas a simple game like Solitaire does not fit in this layer because it does not require the network in order to operate.
- **Presentation Layer (Layer 6)**—This layer is responsible for the coding of data, or translating it into a format that is more secure (sometimes) and efficient for transmission. This layer includes file formats and character representations. From a security perspective, encryption generally takes place at the Presentation Layer.
- **Session Layer (Layer 5)**—This layer is responsible for maintaining communication sessions between computers. It creates, maintains, and disconnects communications that take place between processes on different computers or devices over the network.
- **Transport Layer (Layer 4)**—This layer is responsible for breaking data into packets and properly transmitting them over the network. Flow control and error checking take place at the Transport Layer.
- **Network Layer (Layer 3)**—This layer is responsible for the logical implementation of the network. One very important feature of this layer is logical addressing (covered later in this chapter). In TCP/IP networking, logical addressing takes the familiar form of IP addresses.
- **Data Link Layer (Layer 2)**—This layer is responsible for transmitting information on computers connected to the same local area network (LAN). Device manufacturers assign each hardware device a unique Media Access Control (MAC) address, and this is the layer in which these MAC addresses are used.
- **Physical Layer (Layer 1)**—This layer is responsible for the physical operation of the network. It must translate the binary ones and zeros of computer language into the language of the transport medium by translating data into electrical pulses for copper network cables, bursts

of light for fiber-optic networks, and radio signals for wireless networks.

TIP

An easy way to remember the layers of the OSI Reference Model is with a mnemonic, for example, “All People Seem To Need Data Processing.” If you like food mnemonics better and want to remember the OSI layers starting from the bottom layer (Layer 1), you could use “Please Do Not Throw Sausage Pizza Away.”

The OSI Reference Model enables developers to produce each layer independently. As an example, if you write an email program that operates at the Application Layer, you only need to worry about getting information down to the Presentation Layer. The details of the network you’re using are irrelevant to your program because other software takes care of that automatically. Similarly, if you’re making cables at the Physical Layer, you do not need to worry about what Network Layer protocols will travel on that cable. All you need to do is build a cable that satisfies the requirements of the Data Link Layer.

The Main Types of Networks

A security professional must learn a lot about networking because a good working knowledge about networks and how to secure them is crucial to protecting an organization from network failure or data breach. Many of the devices used in the security field protect networks, and those that do not often rely on them to function. In this section, you will examine the two main types of networks—wide area networks (WANs) and LANs—and explore their function as well as some of the ways to connect a LAN to a WAN. Finally, you will take a brief look at the most important network devices.

Wide Area Networks

As the name implies, WANs connect systems over a large geographic area. **FIGURE 5-2** shows the Internet (the most common WAN), which connects many independent networks together, thus allowing people at different locations to communicate easily with each other. Moreover, the Internet hides the details of this process from the end user. For example, when you send an email message, you do not have to worry about how the data moves. You just click Send and let the network deal with all the complexity.

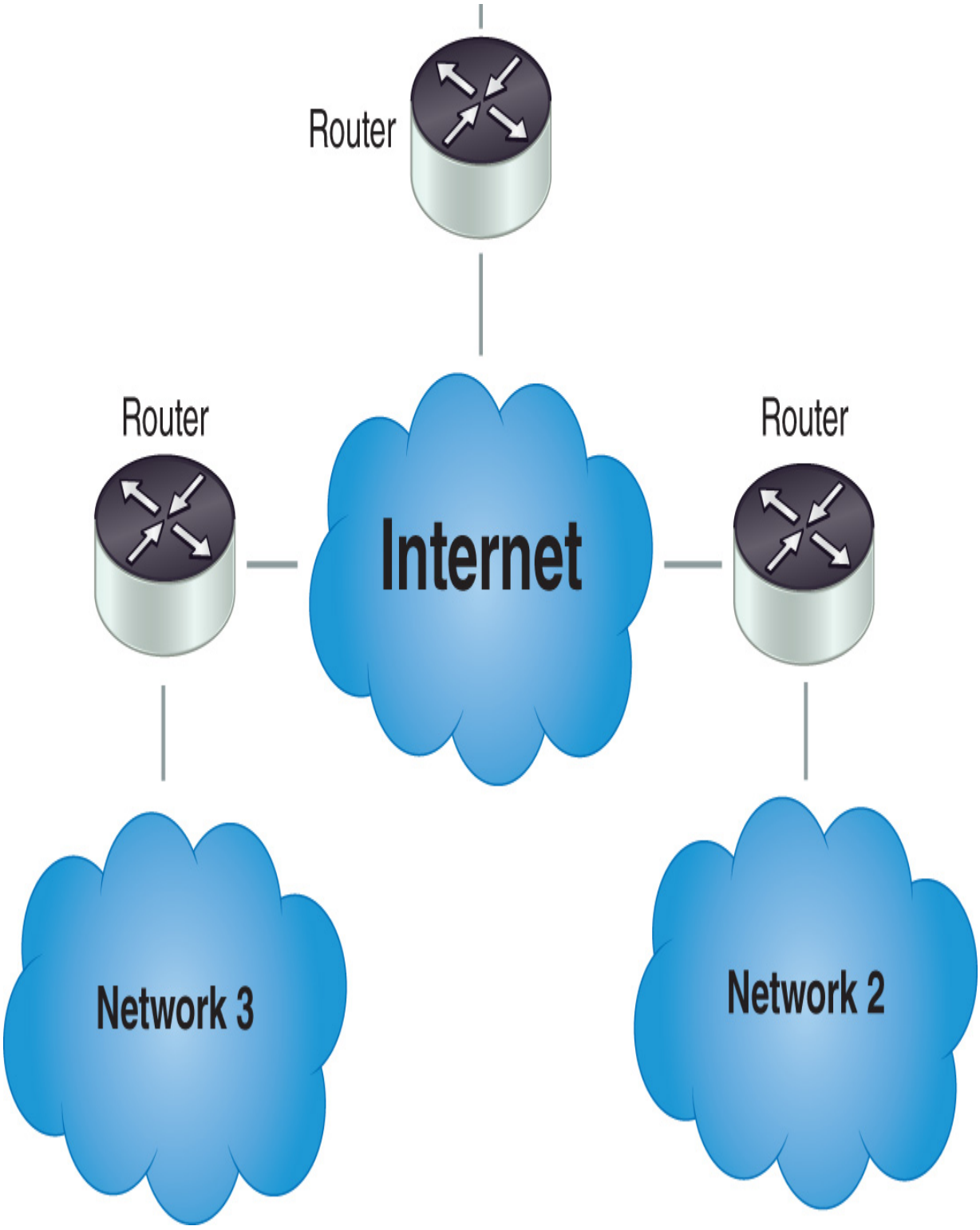


FIGURE 5-2 Wide area networks.

From a security perspective, it's important to remember that the Internet is an open network, which means that, once data leaves the network, its security cannot be guaranteed. The data might travel any path to get to its destination, and anyone might be able to read or modify it along the way. A good analogy for this concept is to think of data on the Internet as being more like a postcard than a letter in a sealed envelope. Fortunately, security technology, such as encryption, enables you to hide the meaning of your data when you're sending it across the Internet, a process that is similar to sending a postcard but writing the message in a secret code. More information about network encryption will follow in the chapter.

Most of today's organizations use the Internet to connect different locations to each other and to connect with their customers. Using the Internet is a low-cost way to connect sites because it is usually easy and inexpensive to connect a network to the Internet; however, you must make sure that you consider the security issues surrounding the use of an open network such as the Internet. Again, encryption technology can help reduce this risk.

Some organizations prefer to use their own private networks for connecting remote sites, either for security reasons or they want the guaranteed reliability of those networks. However, even though this is a very good option for security and reliability reasons, it is also very expensive. An organization can work with a communications provider to develop its own private WAN, and it can also create a virtual private network (VPN) across a WAN (you'll learn about this later in the chapter).

Connectivity Options

There are multiple methods you can use to connect to the Internet. Most home users choose either a cable modem or a digital subscriber line (DSL) from the telephone company, but they can also choose Internet service providers (ISPs), most of which are increasingly providing high-bandwidth Internet service using fiber optics, a service option that enables much faster Internet connections than previous service options. As Internet use increases, ISPs continue to add more connection choices, but, in many cases, the number of available options for connecting to the Internet depends on where a person lives. More densely populated areas tend to offer more options and faster connection speeds. Even if users have no access to cable, DSL, or fiber-optic service, they can still connect to the Internet using satellite or old-

fashioned dialup services (yes, dialup still exists), or they can connect to the Internet through a wireless carrier. Advances in wireless technology make cellular connections affordable in many areas, and service area coverage increases daily.

Smartphones generally connect to third-generation (3G); fourth-generation (4G); and, most recently, fifth-generation (5G) networks, and many of these devices also have the ability to connect to Wi-Fi networks using 802.11 standards. Cellular 3G/4G/5G networks provide stable Internet and voice communication over a wide area. With cellular service, the connection to the Internet appears to be continuous to the user, even while the devices are actually moving from cell to cell. However, many cellular network carriers impose data transfer limits and charge fees for access or slow down connection speeds when users exceed these limits, and, thus, mobile device users often prefer Wi-Fi network connections due to the higher network speed and lower usage costs. Nowadays, it is easy to find free Wi-Fi access at many coffee shops and hotels and in a wide variety of other locations, which helps to make mobile computing a stable option for the average user.

Cellular network Internet connections are very popular with individual users and businesses due to the convenience of mobility. Today's carriers currently offer devices for laptops and mobile access points. In fact, many smartphones and tablets can act as wireless access points for other devices. These mobile access point devices connect to the Internet using a cellular network connection and convert the connection to a Wi-Fi connection for capable devices, which means that you can connect a laptop, smartphone, and several other devices to the Internet anywhere you are located in your carrier's coverage area. This ability can be a huge advantage over using free Wi-Fi because the Internet connection speeds are generally slower using 3G or 4G wireless access devices, whereas the newest 5G devices and networks can provide competitive connection speeds to Wi-Fi. Although 3G and 4G are slower, such connections are far more secure, which makes sharing an Internet connection at a coffee shop with an attacker on the same network less worrisome. Most public Wi-Fi networks are very insecure, so sacrificing a little speed to get a secure connection may be worth it.

Businesses also have many choices for Internet service, and, surprisingly, many of them are the same choices available to home users. For example, most ISPs offer business service in addition to their consumer offerings, but

it is often at a much higher speed than home connections to support the needs of business users. Of course, ISPs generally charge a premium fee for this increased speed.

Again, regarding the OSI Reference Model, the important thing to remember is that the chosen connectivity option will not affect what can be done with the network. Rather, the differences relate to the way the signal gets into the building (i.e., telephone lines, cable lines, dedicated wires, or radio signals) and the speed and reliability of the service.

Routers

A **router** is a device that connects a LAN to a WAN or other networks and selectively interchanges packets of data between them by examining network addresses to decide where to send each packet. The placement of a router within the network architecture affects configuration choices. You can place routers in two basic locations (see **FIGURE 5-3**):

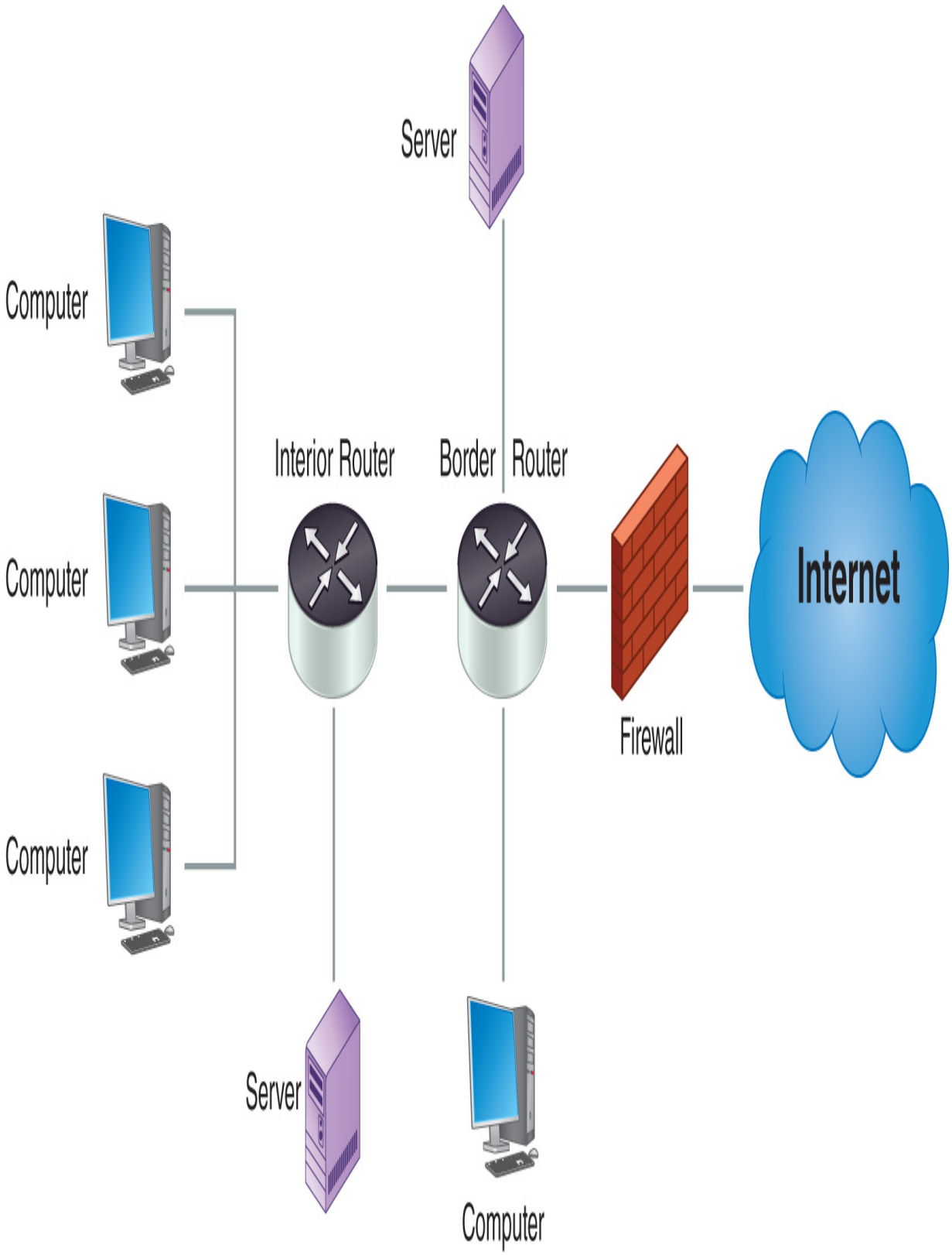


FIGURE 5-3 Router placement.

- **Border routers**—A border router sits between a WAN (normally the Internet) and an internal network. Because a border router is exposed to a WAN, it is subject to direct attack from outside sources. When you configure any router, you should determine whether it is the only point of defense or is one part of a multilayered defense. The latter, of course, is a far better and more secure option because a single defense router can protect some internal resources but is subject to attack itself.
- **Internal routers**—Internal routers can also provide enhanced features to internal networks. They can help keep subnet traffic separate and provide dual protection of keeping undesired traffic out of and desired traffic in a subnet. For example, an internal router that sits between the network of an organization's research department and the network for the rest of the organization can keep the two networks separate, keep confidential traffic inside the research department, and prevent nonresearch traffic from crossing over into the research network from the organization's other networks.

Routers can be configured to allow all traffic to pass or to protect some internal resources and can use **network address translation (NAT)** and packet filtering to improve security. One of the original purposes of NAT was to compensate for a shortage of IP addresses, but, today, NAT's purpose is to hide a system's real **IP address** by using an alternate public IP address. Therefore, an attacker will have more difficulty identifying the layout of networks behind a firewall that uses NAT.

TIP

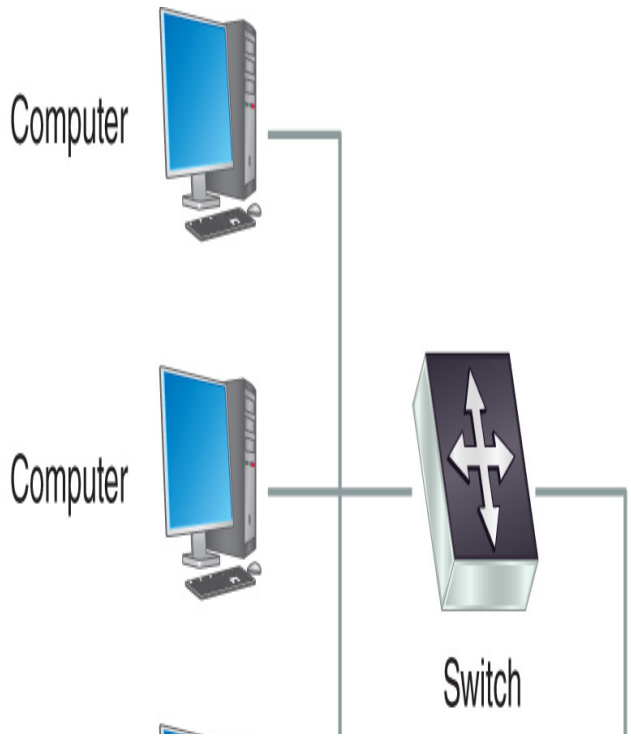
Regardless of where you place routers, you must ensure they are secure. A *secure router configuration* is a collection of settings that ensure that routers are allowing only valid network traffic to flow to and from valid nodes. Therefore, you must configure each router properly and then, because attackers like to reconfigure network devices to allow their attacks to be more successful, monitor to ensure that no unauthorized configuration changes occur.

Another function of a router or firewall is to filter packets, a process that happens each time the router or firewall receives a data packet. The device filters packets by comparing them to rules configured by the network administrator, which tell the device whether to allow or deny the packet into the network. If no rule specifically allows the packet, the firewall blocks it, after which the firewall may send a rejection notice or just silently drop the packet.

NAT and filtering packets are two ways in which routers can be used to help defend a network because they provide some defense against basic attacks. However, because no single technology is a "silver bullet," you should still use firewalls to protect networks and other technologies described in this text to secure data.

Local Area Networks

LANs provide network connectivity for computers that are in the same geographic area and are typically connected to each other with devices such as hubs and switches. This switching infrastructure is located behind the organization's router, as shown in **FIGURE 5-4**.



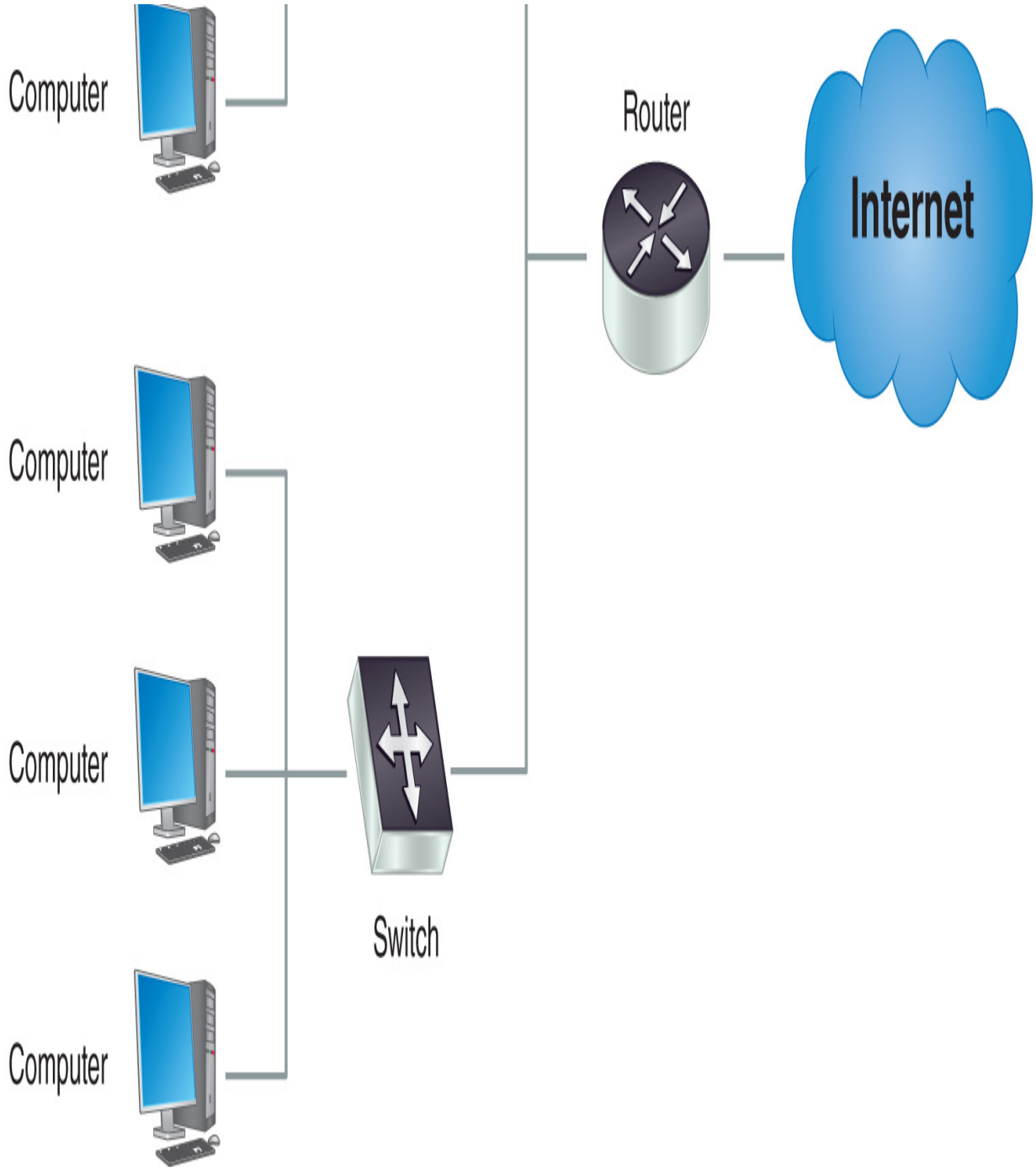


FIGURE 5-4 Local area networks.

In many cases, computers and devices on the same LAN do not protect themselves from each other. They are intentionally configured this way because collaboration between LAN systems often requires connections from the Internet that would not normally be allowed, which is another reason it is

extremely important to have good security on systems located on a LAN. If malware infects one system on the LAN and the other systems do not protect themselves, the malware can spread quickly to all of them.

Ethernet Networks

Through the end of the 20th century, many types of LANs existed, but, today, almost every network has switched to a single technology called Ethernet. In early Ethernet networks, all computers connected to a single wire and had to fight with each other for turns to use the network, which of course was very inefficient. Fortunately, technology has evolved so that, for each system, modern Ethernet networks use a dedicated wire, which connects each one back to a switch that controls a portion of the LAN.

Ethernet has become the most common LAN technology in use, and its standard defines how computers use MAC addresses to communicate with each other on the network and governs both the Physical and Data Link layers of the OSI Reference Model. Even many competing technologies now have variants that run on top of Ethernet. For example, Internet Small Computer System Interface (iSCSI) is a storage networking standard used to link data storage devices to networks using IP for its Transport Layer. An alternative to iSCSI for both optical and electrical networks is fibre channel, which was originally used in supercomputers to connect storage devices but has since spread into common usage across many types of computers. The Fibre Channel over Ethernet (FCoE) protocol makes it even easier than fibre channel to connect fibre channel–capable devices to an Ethernet network, which is yet another example of the way layered network protocols make it easy to implement many types of network devices.

LAN Devices: Switches

The primary LAN device is a **switch**, which is a hardware device that performs the basic function of connecting several systems to the network. Legacy networks from the past century commonly used a device called a **hub**, which simply connected a number of ports to one another and echoed all incoming traffic to all ports. Switches are different from hubs in that they can perform intelligent filtering because they "know" the MAC address of the system connected to each port. When they receive a packet on the network,

they look at the destination MAC address and send the packet to *only* the port where the destination system resides.

Virtual LANs

A virtual LAN (VLAN), which is created in the router and switch configuration setup, is a collection of logically related network devices that are viewed as a partitioned network segment. It gives administrators the ability to separate network segments without having to physically separate the network cabling and can also be used to isolate logical groups of devices to reduce network traffic and increase security. For example, if you create a VLAN for the Human Resources (HR) department, all sensitive information traveling from one HR computer to another HR computer is hidden from all non–HR computers.

TCP/IP and How It Works

Just as people need a common language in order to communicate, so do computers. Fortunately, almost every computer now speaks a standard language (i.e., protocol) called the Transmission Control Protocol/Internet Protocol (TCP/IP).

A **protocol** is a set of rules that govern the format of messages that computers exchange, and a network protocol governs how networking equipment interacts to deliver data across the network. Together, these protocols manage the transfer of data from a server to an endpoint device, from the beginning of the data transfer to the end. In this section, you will learn about the protocols that make up TCP/IP and the basics of TCP/IP networking.

TCP/IP Overview

TCP/IP is not just one protocol but rather a suite of protocols that operate at both the Network and Transport layers of the OSI Reference Model and govern all activity across the Internet and through most corporate and home networks. It was developed by the U.S. Department of Defense to provide a highly reliable and fault-tolerant network infrastructure, for which reliability, not security, was the focus.

TCP/IP has several responsibilities, as illustrated in **FIGURE 5-5**, which shows a portion of the suite. Note that TCP isn't the only protocol that runs over IP. Use Datagram Protocol (UDP) works alongside TCP at the Transport Layer to support upper-level protocols. These two common protocols provide different types of transport services and are useful in different scenarios. Also, note that not all protocols in this figure, such as Telnet and File Transfer Protocol (FTP), are secure. Always choose protocols based on their ability to support secure communication.

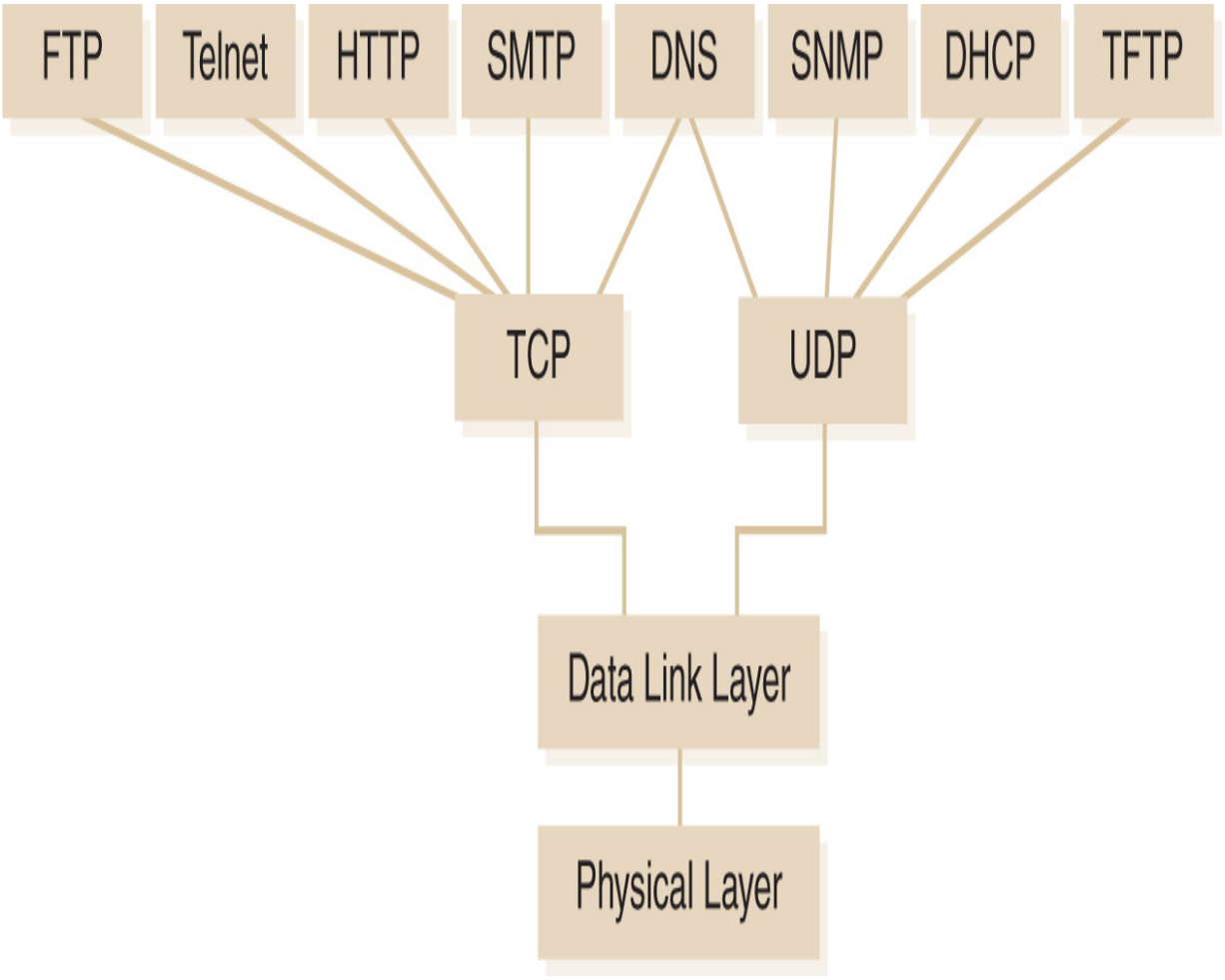


FIGURE 5-5 TCP/IP protocol suite.

IP Addressing

One of the primary functions of Network Layer protocols is to provide an addressing scheme, and TCP/IP is located in this layer. There are two versions of the IP protocol, and thus IP address formats, in use today. IP version 4 (IPv4) is still the more common version, even though its addressing space was exhausted in 2011, over 10 years ago, but its replacement version, IP version 6 (IPv6), is gaining in popularity and percentage of Internet traffic. Currently, in 2021, IPv6 makes up only 32 to 35 percent of total Internet traffic, with its slow adoption being caused primarily by legacy applications that are dependent on IPv4. Even so, most countries prefer and continue to roll out IPv6-capable networks, so adoption is coming. All told, even in the 2020s, it's still worthwhile to learn how IPv4 addressing works.

An **IPv4 address** is a 4-byte (32-bit) address that uniquely identifies every device on the network. With an explosion in the number of network devices during the end of the past century, it was clear that IPv4 would not accommodate unique addresses for each device, which is one of the reasons IPv6 was developed. **IPv6 addresses** are 128 bits long and can provide far more unique device addresses than the older standard as well as containing many additional features and being more secure.

FIGURE 5-6 shows the difference between the notation for an IPv4 and IPv6 address. As you can see, IPv4 addresses use the dotted-quad notation, which represents each of the 4 bytes as an integer between 0 and 255. Moreover, each IPv4 address consists of a network address and a host address. For example, the IPv4 address 192.168.10.1, shown in the figure, is for the network address 192.168 and the host address 10.1. The dividing line between the network and host addresses is a network configuration parameter known as the subnet mask, which can change based on the way an administrator configures the network. All hosts that share the same network address are part of a **subnet**, which is a partition of a network based on IP addresses. Because IPv6 addresses are so much larger than IPv4 addresses, IPv6 uses a completely different notation. As shown in the figure, IPv6 addresses are expressed as hexadecimal values, separated into eight groups of 16 bits, whereas IPv4 addresses consume only the two rightmost groups of 16 bits of an IPv6 address. The difference between the number of addresses available in IPv4 and IPv6 cannot be illustrated in a simple figure. Think of it this way: If you could write every IPv4 address in a two-inch-square block, the space you would need to write all IPv6 addresses, using the same font, would be about as big as the solar system.

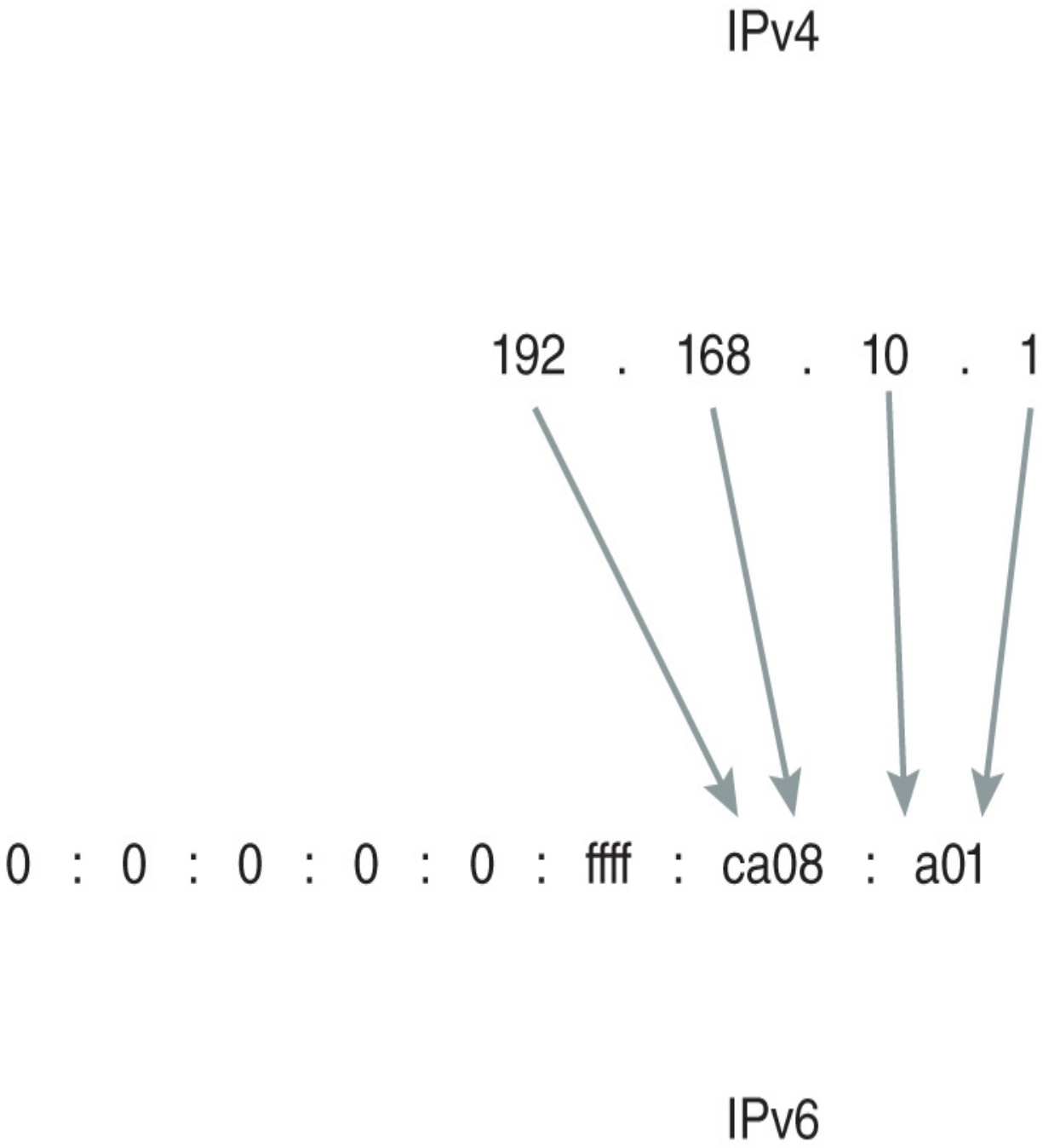


FIGURE 5-6 IP addressing.

Because every computer needs its own IP address, keeping track of address assignments can become time consuming; therefore, many organizations that use IPv4 use the **Dynamic Host Configuration Protocol (DHCP)** within a network to simplify the configuration of each user's computer. This protocol allows each computer to get its configuration

information dynamically from the network instead of the network administrator's providing the configuration information to the computer. DHCP provides a computer with an IPv4 address, subnet mask, and other essential communication information, which greatly simplifies the network administrator's job. An example of DHCP communication appears in **FIGURE 5-7**. Technically, DHCP works only with IPv4 networks, whereas DHCPv6 provides IPv6 addresses.

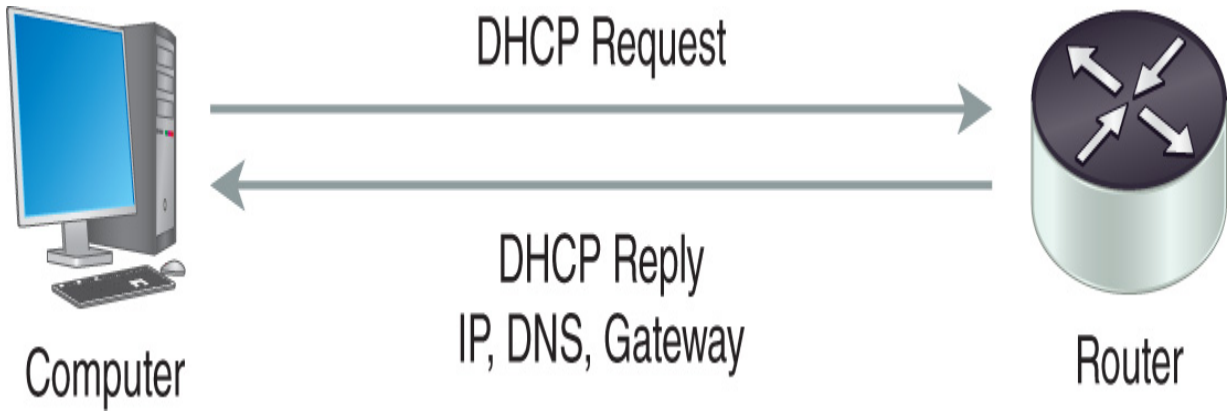


FIGURE 5-7 DHCP communication.

NOTE

The Internet Assigned Numbers Authority (IANA) has released only about 20 percent of the available IPv6 addresses for use. While this addressing restriction may suggest a limit on available IPv6 addresses, remember that IPv6 addresses are 128 bits long, which allows for 128-bit (2,128) addresses, or 3.4 × 1,038 unique IP addresses. That would mean, even with making the first few bits static, there are still trillions of trillions of IPv6 addresses for every person on Earth! Much more information on IPv6 is available on IANA's dedicated IPv6 site at *www.arin.net/resources/guide/ipv6/*.

Common Ports

Computers and devices that are connected to networks commonly use the network for more than one purpose, and software application programs use the network to communicate with many other remote services running on remote computers and devices. Because any network computer or device may host several services, programs need a way to tell one service from another. Therefore, to differentiate services running on a device, networking protocols use a **network port**, which is just a number that tells a receiving device where to send messages it receives. Once the address of the remote device is known, client software sends network messages to specific ports, and server software listens to ports for incoming messages. For example, almost all unencrypted traffic between web browsers and web servers uses port 80, which is commonly used for Hypertext Transfer Protocol (HTTP) traffic. No one forces software to use the common ports, but most use them to make it easy for clients and servers to communicate. **TABLE 5-1** lists ports that common services use.

TABLE 5-1 Common port numbers.

PORT	SERVICE/USE
20	FTP data transfer
21	FTP control
22	Secure Shell (SSH)
23	Telnet
25	Simple Mail Transfer Protocol (SMTP)
53	Domain Name System (DNS)
67/68	Dynamic Host Configuration Protocol (DHCP)
80	Hypertext Transfer Protocol (HTTP)
88	Kerberos
110	Post Office Protocol v3 (POP3)
139	Network Basic Input/Output System (NetBIOS) Session Service
143	Internet Message Access Protocol (IMAP)
161	Simple Network Management Protocol (SNMP)
162	SNMP Trap
443	HTTP over Secure Sockets Layer/Transport Layer Security (SSL/TLS)
445	Simple Message Block (SMB) over IP
3389	Terminal Server

Common Protocols

You have learned about some of the most common network protocols, but there are many more protocols that define communication rules for many uses. Although the list in **TABLE 5-2** is not comprehensive, it does include some of the more common and recognizable network protocols.

Technical TIP

Notice that there is no port number listed for SSL or TLS, the reason being that these two protocols are used to provide encryption for higher-level protocols. For example, HTTPS is just HTTP running over SSL or TLS, which means that SSL or TLS will use just the HTTP port (80). Conventionally, HTTPS from a client browser to the server uses port 443. However, the port itself means nothing with regard to security; the SSL protocol is what encrypts the HTTP data. SSL has been around longer than the more secure TLS but is slowly being replaced by it.

TABLE 5-2 Common network protocols.

PROTOCOL	COMMON PORT(S)
DNS (Domain Name System)	53
FTP (File Transfer Protocol)	20 (data), 21 (control)
FTPS (FTP over SSL/TLS)	989 (data), 990 (control)
HTTP (Hypertext Transfer Protocol)	80
HTTPS (HTTP over SSL/TLS)	443
iSCSI (Internet Small Computer System Interface)	860; 3,260 (target)
NetBIOS (Network Basic Input/Output System)	137 (Name service) 138 (Datagram service) 139 (Session service)
SCP (Secure Copy—part of SSH)	22
SFTP (Secure File Transfer Protocol—part of SSH)	22
SNMP (Simple Network Management Protocol)	161
SSH (Secure Shell)	22
Telnet	23
TFTP (Trivial File Transfer Protocol)	69

Internet Control Message Protocol

Once you have configured all the network components, you need to monitor the network for health and performance, which can be done using the **Internet Control Message Protocol (ICMP)**. ICMP is a management and control protocol for IP that delivers messages between hosts about the health of the network. The messages carry information on hosts ICMP can reach as well as information on routing and updates.

NOTE

The IANA maintains a list of well-known services and port numbers. You can find this list at *www.iana.org/assignments/service-names-port-numbers/service-names-port-numbers.xhtml*.

Two ICMP tools are *ping* and *traceroute*. The ping command sends a single packet to a target IP address called an **ICMP echo request**. This packet is equivalent to asking the question "Are you there?," to which the computer on the other end can either answer yes, by sending an ICMP echo reply packet, or ignore. Because attackers sometimes use the ping command to identify targets for a future attack, many system administrators configure their computers to ignore all such requests.

The traceroute command uses ICMP echo request packets for an entirely different purpose: to identify the path that packets travel through a network. Packets may travel several routes to get from one point on a network to another, and the traceroute command is used to display the path that a particular packet follows so you can identify the source of potential network problems.

Attackers can use ICMP to create a denial of service (DoS) attack against a network. This type of attack is known as a *smurf attack*, named after one of the first programs to implement it. It works by sending spoofed ICMP echo request packets to a broadcast address on a network, hoping that all the hosts on that network will respond. If the attacker sends enough replies, it is

possible to bring down a large network from any Internet-connected device. Fortunately, it is very easy to defend against smurf attacks by configuring a network to ignore ICMP echo requests sent to broadcast addresses.

Network Security Risks

Any data in transit presents a potential attack target, which is the very reason that network security is so important. So far, in this chapter you've learned about how networks carry data and about a few risks facing networks, such as smurf attacks. This section will provide an in-depth look at network security risks as well as cover some of the network security controls that you can put in place to protect a network.

NOTE

Attackers want to gain control of systems on a network because, by controlling computers and devices, they can control the data as well. To achieve their goals, they will exploit network security holes, a discussion of which is beyond the scope of the chapter.

TIP

Historically, network security separated the "good guys" from the "bad guys." Employees, contractors, and partners (and their devices) were generally trusted, and only the anonymous users were explicitly untrusted. As attackers increasingly compromised trusted users to infiltrate networks, security got more complex so that, now, network security philosophy suggests viewing every network as a *zero trust network*, meaning one in which no user or device is implicitly trusted and every user and device must provide a reason to be trusted. Adopting this approach makes it harder for attackers to "sneak into" a network.

Categories of Risk

The three main categories of network security risk are reconnaissance, eavesdropping, and DoS. Each of these risks has different impacts on the confidentiality, integrity, and availability (C-I-A) of data carried across a network and may affect the security of the network itself.

Reconnaissance

Reconnaissance involves an attacker's gathering information about a network for use in a future attack. As an illustrative analogy, consider an army that wants to attack a country. To be successful, the attacking military forces need to gather advance information about their adversary, some of which may include the following:

- Terrain
- Location of roads, trails, and waterways
- Locations and types of enemy defenses
- Weaknesses in the enemy's perimeter
- Procedures for allowing access through the perimeter
- Types of weapons used by the enemy

Similarly, a network attacker would want to know many things before attacking, such as the following:

- IP addresses used on the network
- Types of firewalls and other security systems
- Remote access procedures
- Operating system(s) of computers on the network
- Weaknesses in network systems

Normally, you would not simply make this information available to an attacker, and, therefore, the attacker must employ many tools to obtain it. One such tool is ICMP echo requests, which have already been covered as to why it is important to block them when they are received from outside the organization's network. By taking this simple action, attackers are stopped

from using the ping and traceroute tools to gather information. Another effective strategy to limit the effectiveness of network reconnaissance attacks is to configure systems to provide as little information as possible to outsiders.

Eavesdropping

Attackers might also want to violate the confidentiality of data sent on the network. Again, as an illustrative analogy of network eavesdropping, consider a less complex technology—the telephone. A telephone is easy to tap by hooking up a cable to the telephone switch box on the building and connecting a handset to listen in on calls.

Network eavesdropping is actually easier than telephone eavesdropping because, even though physical access to the network makes it easier to eavesdrop, it is not required. An attacker can compromise a computer on the network and use that computer for eavesdropping. Following are a few options that you can use to protect against this type of attack:

- Limit physical access to network cables.
- Use switched networks. The attacker will then see only information sent to or from the computer attached to the tapped cable.
- Encrypt sensitive data. The attacker still might be able to see the transmission but will not be able to make sense of it.

Using switched networks and encryption will help limit the effectiveness of this type of attack as well as securing systems on the network from malicious code.

Denial of Service

Often, an attacker is not interested in gaining access to the network but, instead, wants to deny its use, which can be an extremely effective tactic because many businesses cannot operate if they lose their networks. An attacker has two primary methods to conduct a DoS attack: flooding a network with traffic and shutting down a single point of failure.

NOTE

Wireless networking presents a completely new world of eavesdropping challenges. You will learn more about that topic later in the chapter.

To make a network unavailable, flooding it with traffic is the simpler of the two methods. A network is like a pipe in that it can carry only so much data before it gets full. Knowing this information, attackers can create a DoS attack by simply sending more data through a network than it can handle. A variation on this theme is a distributed denial of service (DDoS) attack. In this type of attack, black-hat hackers use many systems around the world that they have compromised to flood the network from several directions, making it difficult to distinguish legitimate from attack traffic and, therefore, eventually halting the processing of data on the network.

Even though DDoS attacks have been around for years, they are not considered old types of attacks and are still used to slow down or disable their victims. Today, hacktivists, or activists with hacking abilities, are behind increasing numbers of large-scale attacks to attract attention, generally to a political issue. One such attack came in mid-March of 2020 when a group of hacktivists launched a series of DDoS attacks against the U.S. Department of Health and Human Services (HHS) website. This attack was intended to stop U.S. citizens from getting up-to-date official information on COVID-19 policies and guidelines and to protest rumored nationwide shutdowns to help control the pandemic. Fortunately, HHS was prepared for such attacks and was able to withstand the onslaught of network traffic.

Other DDoS attacks in 2020 focused on various U.S. human rights organizations and often coincided with political and social justice protests that occurred throughout the year. Information technology (IT) service organizations have also become attractive targets because many of their clients are targets of hacktivists. One such company, Cloudflare, which provides anti-DDoS services, was the target of a large DDoS attack that started on June 18, 2020, and lasted four days; at its peak measurement, 754 million packets per second were coming from 316,000 IP addresses. As with

the HHS attack, Cloudflare was properly prepared to fend off the massive attack, which, unfortunately, not all organizations are.

Advances in technology have provided even more opportunities for attackers to cause problems with DoS attacks. One type of attack, the *telephony denial of service (TDoS) attack*, which can be dangerous for essential services, started to become prevalent in 2013 and has become more common in recent years. In a TDoS attack, the attacker attempts to prevent telephone calls from being successfully initiated or received by a person or an organization that depends on telephone calls as a primary mode of communication. Such an attack can disrupt or totally disable telephone communications, thus causing an enormous impact to an organization, such as revenue loss, potential fines, the inability to conduct operations, and a loss of customer confidence. In February 2021, the U.S. Federal Bureau of Investigation (FBI) announced a public warning about TDoS attacks being disruptive to 911 emergency call services.

Protecting an organization against a DoS attack can be difficult, but the most obvious approach is to ensure that the Internet bandwidth is adequate to withstand an extreme load. Some new technologies on the market seek to defend against DDoS attacks, but they are unproven and limited in their effectiveness. The best defense is to detect attacks as early as possible and take action to block the incoming traffic before it renders the network unusable.

Basic Network Security Defense Tools

Defense against these kinds of risks begins with some basic hardware and software tools, such as firewalls, virtual private networks (VPNs), and network admission control.

Firewalls

A **firewall** controls the flow of traffic by preventing unauthorized network traffic from entering or leaving a particular segment of a network. You can place a firewall between an internal network and the outside world or within internal subnetworks to control access to particular corporate assets by only authorized users. Firewalls are critical elements of networking security, but they are just that, elements; they will not solve all security problems, but they do add a much-needed deterrent.

FIGURE 5-8 shows the role of a firewall in a network, which is to separate private networks from the Internet as well as to separate different private networks from each other. This section covers the different types of firewalls and the roles they play in the network topology.

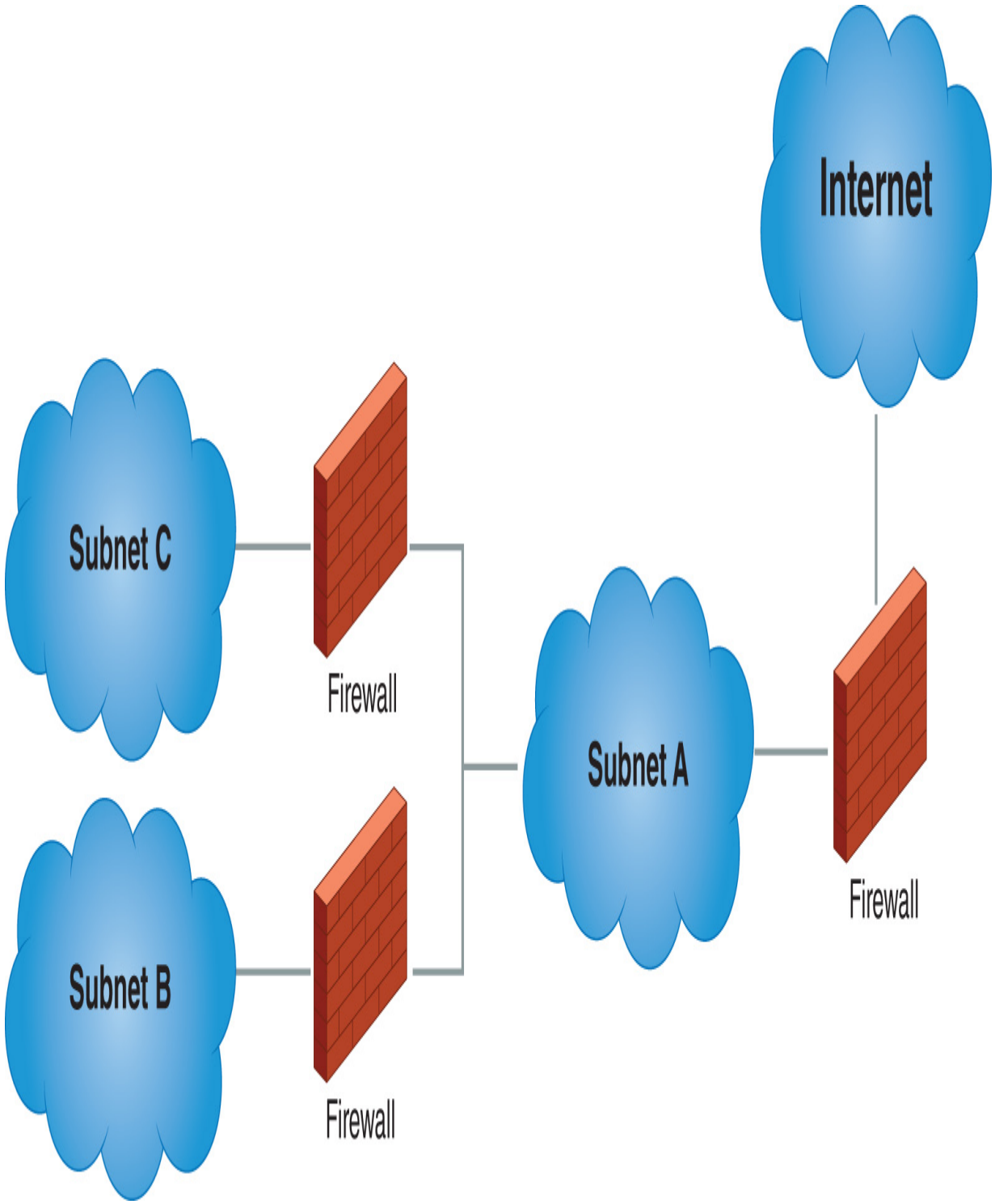


FIGURE 5-8 Firewalls.

Firewalls can be very powerful tools in securing networks. Because each firewall is configured using rules, it provides the most common way to

implement rule-based management, which means simply managing the security of a network by defining rules of what network traffic is and is not acceptable. Firewall rules are filters, defined in a firewall's configuration, that make it easy to implement many of these security requirements. Different types of firewalls use different types of rules, but even the simplest firewalls support access control lists (ACLs), which define rules for handling traffic from one or more hosts using a specific protocol and one or more ports. In addition to securing a host, firewalls can also filter traffic based on ports, often called port security. ACLs can contain very specific rules for a single host, protocol, and port or may contain ranges of hosts and ports with multiple protocols. Each rule tells the firewall how to handle certain types of messages, with the most common actions being allowing and denying. To create the most secure network, configure the firewall to deny all messages except the ones that are explicitly allowed, an approach called implicit deny. This approach can be very secure, but it requires more effort on the part of network administrators to open ports as needed.

Firewalls can help secure networks in several ways, a few of which have already been covered. In addition to these filtering features, they can also provide the following:

- **Flood guard**—Rules can limit traffic bandwidth from hosts, thus reducing the ability for any one host to flood a network.
- **Loop protection**—Firewalls can look at message addresses to determine whether a message is being sent around an unending loop, which can be another form of flooding.
- **Network segmentation**—Filtering rules enforce divisions, or separations, between networks, thus keeping traffic from moving from one network to another.

Firewall Types

The basic function of a firewall is quite simple—to block any traffic that is not explicitly allowed. Firewalls contain rules that define the types of traffic that can come and go through a network, and, each time the firewall receives a network message, it checks the message against its rules. If the message

matches a rule, the firewall allows it to pass, whereas, if the message does not match a rule, the firewall blocks it.

Going beyond this basic functionality, firewall technology includes three main types:

- **Packet filtering**—A **packet-filtering firewall** is very basic. It compares received traffic with a set of rules that define which traffic it will permit to pass through the firewall. It makes this decision for each packet that reaches the firewall and has no memory of packets it has encountered in the past.
- **Stateful inspection**—Unlike the packet-filtering firewall, a **stateful inspection firewall** remembers information about the status of a network communication. Once the firewall receives the first packet in a communication, the firewall remembers that communication session until it is closed. This type of firewall needs to check rules only when a new communication session starts, not each time it receives a packet.
- **Application proxy**—An **application proxy firewall** goes even further than a stateful inspection firewall in that it does not actually allow packets to travel directly between systems on opposite sides of the firewall. Instead, it opens separate connections with each of the two communicating systems and then acts as a broker (or proxy) between the two, which allows for an added degree of protection because the firewall can analyze information about the application in use when making the decision to allow or deny traffic.

Firewalls are not simply preventive controls; instead, they also operate as detective controls and can log as much information as can be analyzed. A structured log analysis process can help identify reconnaissance activity or even attacks that have already occurred. You should regularly monitor all firewall logs to identify potential problems. Because log files from firewalls and other network devices can become very large, using automated log monitors and analysis tools helps to efficiently sort through the log data.

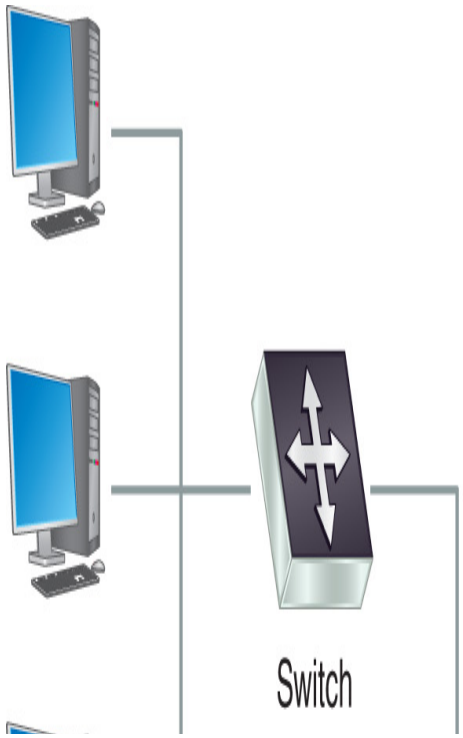
The type of firewall chosen for a network will depend on many factors. If you're placing a simple firewall at the border of a large network, you may want to use a basic packet filter. On the other hand, if you're protecting a highly secure data center that hosts web applications, an application proxy might be more appropriate.

Firewall Deployment Techniques

You can deploy firewalls in several ways on a network. This section will cover three of the most common firewall deployment techniques—border firewalls, screened subnet (or DMZ) firewalls, and multilayered firewalls. Depending on an organization's security needs, one or more of these approaches may be a good fit.

Border Firewall.

The **border firewall** is the most basic approach. These firewalls simply separate the protected network from the Internet, as shown in **FIGURE 5-9**; they normally sit behind the router and receive all communications passing from the router into the private network as well as all communications passing from the private network to the Internet. Border firewalls normally use either packet filtering or stateful inspection.



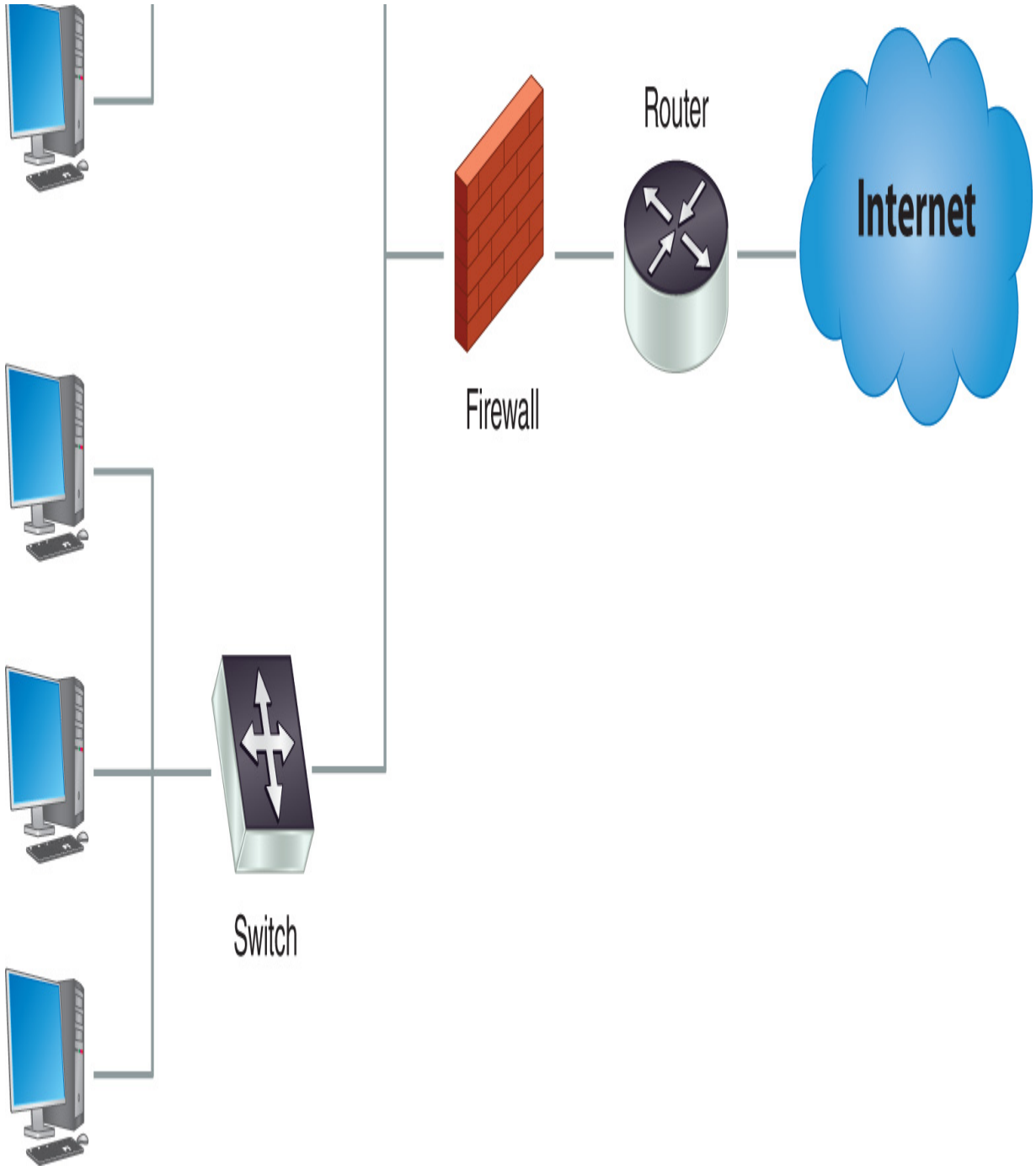


FIGURE 5-9 A border firewall.

Border firewalls are most common for organizations that do not host public services. If an organization outsources its website and email and does not provide any Internet-facing services, it might not need to allow the public access to the network at all. In this case, simply blocking most (or sometimes

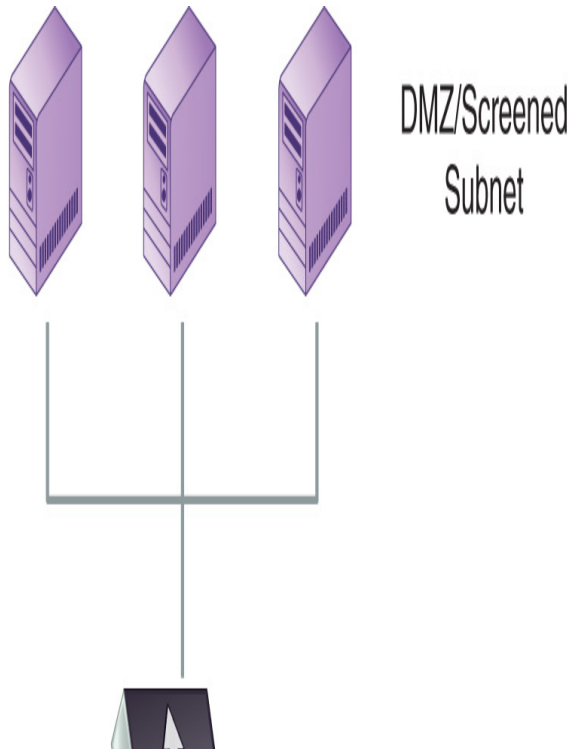
all) inbound traffic is all that is necessary, and a border firewall excels in this scenario.

Screened Subnet.

Often, it's not possible to block all traffic into a network, such as when an organization hosts a public website or its own email server, thus making it necessary to allow inbound connections on a limited basis. The screened subnet firewall topology, shown in **FIGURE 5-10**, is the best approach for this type of requirement. This firewall has three network interfaces. Two are set up identically to a border firewall, with one of them connected to the Internet and the other connected to the private network. The third interface connects to a special network known as the screened subnet, or **demilitarized zone (DMZ)**.

NOTE

The screened subnet is the most common firewall topology in use today.



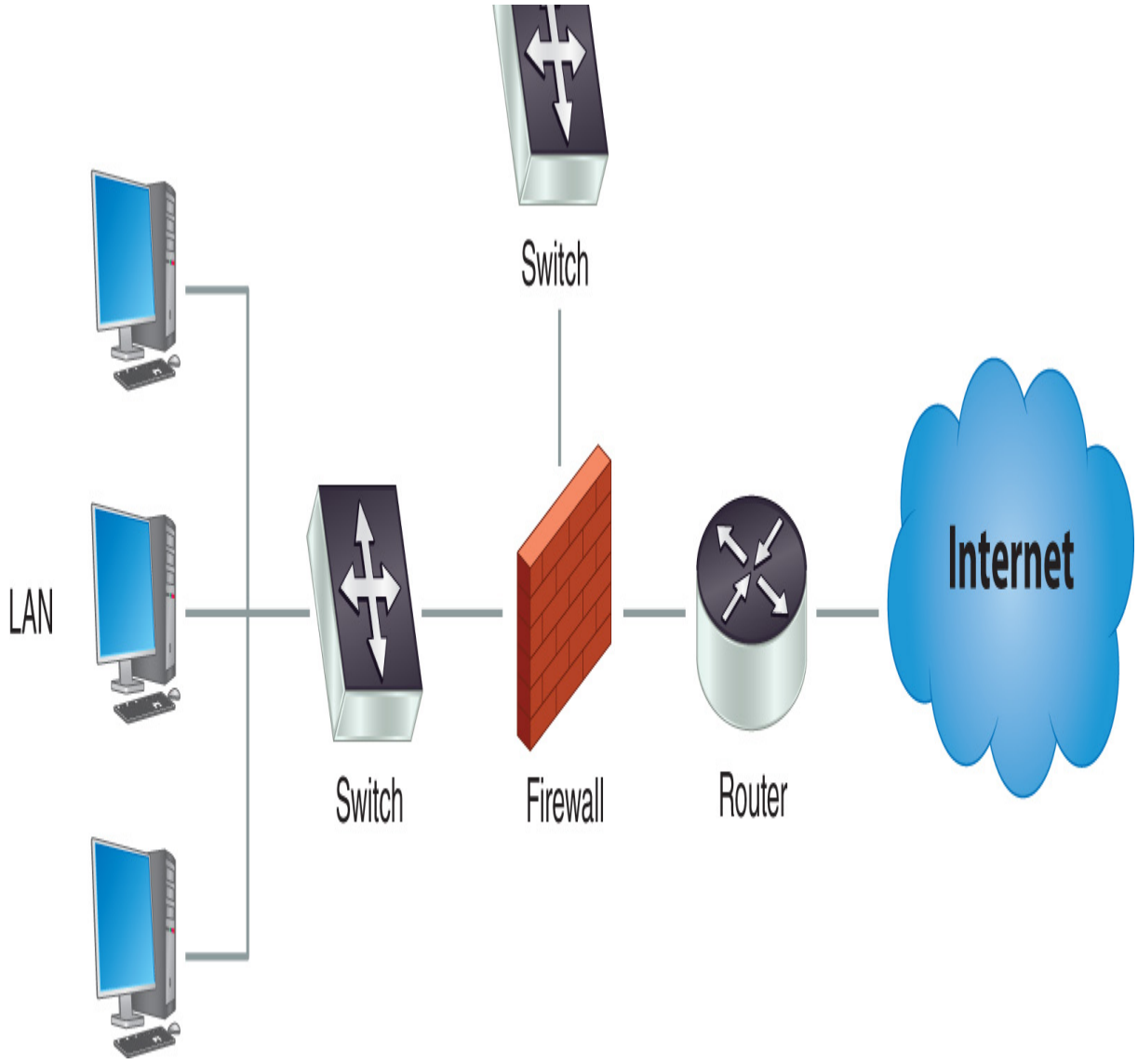


FIGURE 5-10 A screened subnet firewall.

The DMZ is a semiprivate network used to host services that the public can access. Thus, users are allowed limited access from the Internet to systems in the DMZ but are blocked from gaining direct access from the Internet to the private network by a secure network.

This approach recognizes that systems accessed from the Internet pose a special risk because they are more likely to be targets of attacks and, therefore, more likely to suffer successful ones. If these machines are confined to the DMZ, then the only other systems they can jeopardize are those also in the DMZ. Therefore, an attacker who gains access to a DMZ

system will not be able to use that system to directly access systems on the private network.

Multilayered Firewalls.

In large and/or highly secure environments, organizations often use multiple firewalls to segment their network into pieces. This is the case illustrated in Figure 5-8, which shows that one firewall acts as the border firewall, protecting subnets A, B, and C from the Internet, and the other two firewalls separate subnets B and C from each other and from subnet A.

Multilayered firewalls are useful when networks have different security levels. For example, referring to Figure 5-8, general users may connect to subnet A, users working on a secret research project might connect to subnet B, and executives might connect to subnet C. This structure provides the secret project and the executives with protection from the general user community.

Unified Threat Management.

Firewalls are so important to network security that they have matured into devices that do far more than just inspect packets. In fact, multipurpose firewalls are more commonly referred to as unified threat management (UTM) devices. These devices do provide filtering as well as many other security services, some of which follow:

- **URL filter**—This feature filters web traffic by examining the Uniform Resource Locator (URL) as opposed to the IP address.
- **Content inspection**—The device looks at some or all network packet content to determine whether the packet should be allowed to pass. This type of inspection can help identify malicious content from trusted sources, which could happen if a trusted source is compromised.
- **Malware inspection**—Providing a specialized form of content inspection, the device looks at packet content for signs of malware.

These unified services make it possible to reduce the number of devices that must analyze network packets. Fewer UTM devices can provide the same level of security as many older devices. However, even with fewer devices inspecting packets, introducing UTM devices can slow down a network

because of the sheer amount of work the devices must accomplish. It takes time to inspect and analyze each network packet at multiple layers of the network stack. For this reason, some organizations have elected a "middle-of-the-road" approach, such as implementing a web security gateway, which performs URL filtering but does not examine the content of the packets and therefore accomplishes some of what a UTM device does but without all the overhead.

NOTE

Another useful feature of firewalls is that they can be configured as load balancers, which can dynamically route network traffic to different network segments to avoid congestion. They do this by monitoring known network segments and directing traffic onto a segment that is appropriate for the destination host and has the necessary bandwidth, a process that can keep networks from slowing down when the demand is high.

Virtual Private Networks and Remote Access

With the advent of telecommuting, remote access has become a common part of many corporate networks. When the COVID-19 pandemic hit, the migration toward support for a remote workforce had already begun, and the pandemic simply accelerated support for remote and distributed workers to keep business functions from completely stopping. Today, many companies have employees who rarely if ever come into the corporate office, instead working at home or on the road. Even so, they still need access to corporate resources, which means opening access to more corporate resources from the Internet than IT professionals are comfortable with. The trick is to allow corporate personnel the access they need but to keep attackers out of these potentially open doors.

Virtual private networks (VPNs) are an effective way to increase the security level of data that is transmitted across a public data network by using encryption to protect all the data sent between a user and the

organization's network. The cost difference between using a VPN and paying for a dedicated connection between two sites is significant. Therefore, using a VPN for remote access not only provides security but is also cost effective. **FIGURE 5-11** shows an example of VPN access to a network.

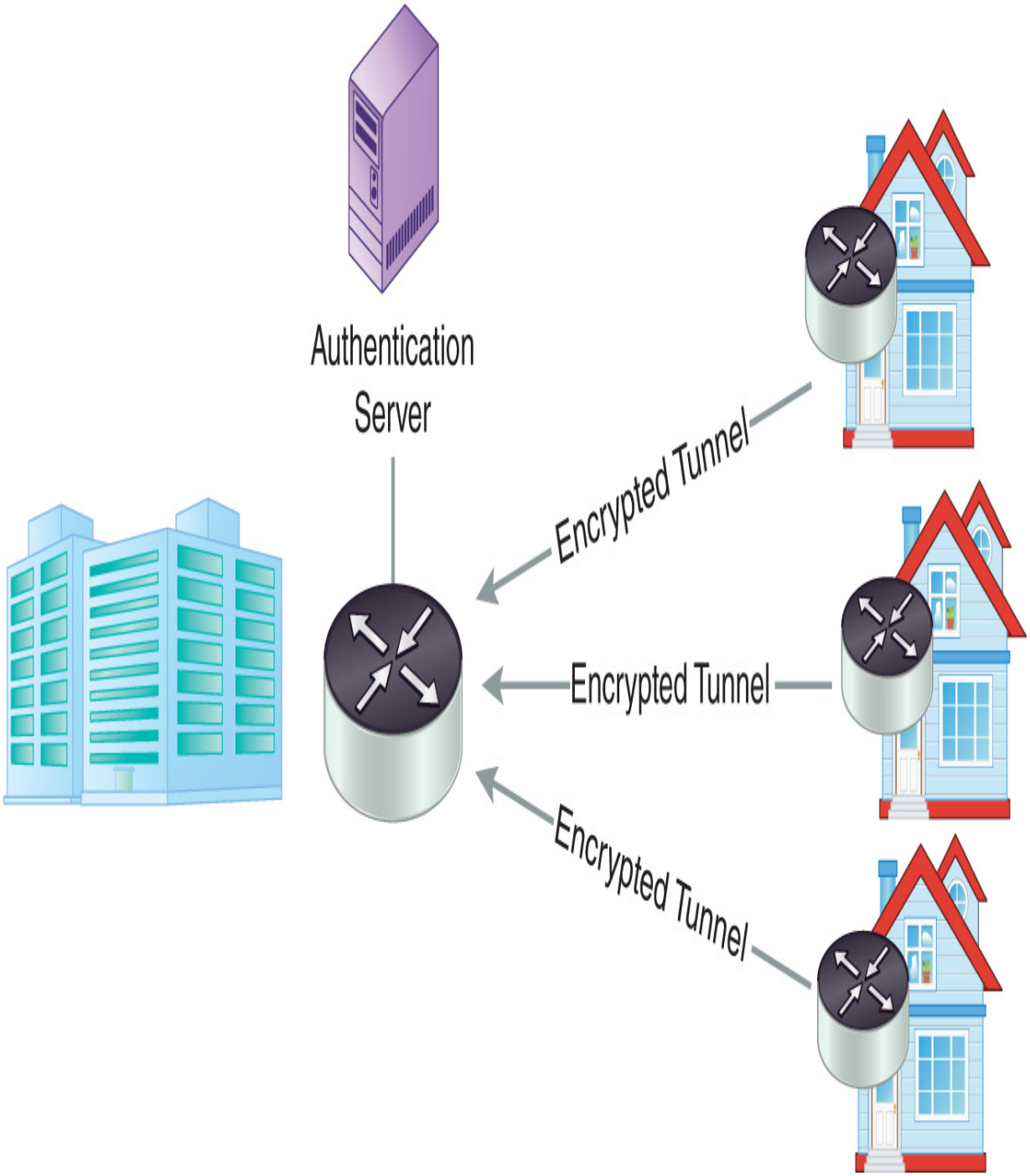


FIGURE 5-11 VPN access.

VPNs require gateway equipment with high processing power to handle the encryption algorithms. You can offload this processing power to another device by using a dedicated VPN concentrator rather than having the router or firewall terminate the VPN.

In deploying a VPN, the security of the end users' computers must be considered because, once users connect to the corporate network, their computers could be open portals into those resources for an attacker who gains access to them. For this reason, many organizations require that employees install security software on their home computers as well as limiting VPN access to laptop computers that the organization owns and manages.

Following are the major VPN technologies in use today:

- **Point-to-Point Tunneling Protocol (PPTP)**—The PPTP was once the predominant VPN protocol and almost all VPNs used it. It is easy to set up on client computers because most operating systems include PPTP support.
- **Secure Sockets Layer (SSL)/Transport Layer Security (TLS)**—The **Secure Sockets Layer (SSL)/Transport Layer Security (TLS)** protocol encrypts web communications, and many VPNs use it. Users connect to an SSL/TLS-protected webpage and log on. Their web browser then downloads software that connects them to the VPN. This setup requires no advance configuration of the system. For this reason, SSL/TLS VPNs are quickly growing in popularity.
- **Secure Socket Tunneling Protocol (SSTP)**—Microsoft's SSTP is available only for the Windows operating system. This protocol is a more modern approach to VPNs that route traffic over SSL, which makes it easy to set up VPN connections that can go through firewalls and proxy servers.
- **Internet Protocol Security (IPSec)**—**Internet Protocol Security (IPSec)** is a suite of protocols designed to securely connect sites. Although some IPSec VPNs are available for end users, they often require the installation of third-party software on the user's system and, therefore, are not popular. The required IPSec VPN functionality is built into many routers and firewalls, allowing for easy configuration.

- **OpenVPN**—OpenVPN is an open source VPN protocol that is available for most current operating systems. It uses SSL/TLS for its preshared key exchange process and then sets up a tunnel for communication. Two versions are available, OpenVPN TCP and OpenVPN UDP, to support the two most common transport protocols.

VPNs provide clear benefits to an organization by offering an inexpensive, secure replacement for dedicated connections between sites and enabling users to connect securely to the organization's network from remote locations. Being able to securely connect from remote locations promises increased productivity because workers can easily get to resources they need while on the road.

Network Access Control

Network access control (NAC) systems enable you to add more security requirements before allowing a device to connect to a network. These systems perform two major tasks—authentication and posture checking—and work on both wired and wireless networks. Although NAC is a new technology, it is growing in popularity, and many organizations now deploy NAC for both internal users and guests using their network.

The IEEE 802.1x, commonly referred to as simply 802.1x or 1x, standard governs how clients, through the authentication component of NAC, may interact with a NAC device to gain entry to the network. The authentication process involves software on users' computers that prompts them to log on to the network. After verifying the users' credentials, the NAC device then instructs the switch (for a wired network) or access point (for a wireless network) to grant the user access to the network.

Posture checking is an optional second use of NAC technology. When posture checking is used, the NAC device checks the configuration of the user's computer to ensure that it meets security standards before allowing it access to the network. Following are some things commonly checked:

- Up-to-date antivirus software
- Host firewall enabled
- Operating system supported

- Operating system patched

If a user attempts to connect a noncompliant system to a network, the NAC device offers two options: either the administrator can decide to block such systems from the network until they are fixed, or the system can connect to a special quarantine network where it can be fixed before gaining access to the main network. One of the most common protocols that NAC devices use to authenticate devices is the **Extensible Authentication Protocol (EAP)**. EAP is an authentication framework, not a specific protocol implementation, that defines the transport of keys and authentication credentials used by other protocols, such as wireless network authentication, and exists in several variations. Such variations include EAP Flexible Authentication via Secure Tunneling (EAP-FAST), which is an EAP extension that sets up a secure tunnel to protect the authentication process; EAP Transport Layer Security (EAP-TLS), which uses TLS to secure authentication credentials; EAP Tunneled Transport Layer Security (EAP-TTLS), which extends TLS to create a tunnel for authentication; and the Protected Extensible Authentication Protocol (PEAP), which is basically EAP running in a TLS tunnel but providing more security than EAP for authentication exchanges.

Voice and Video in an IP Network

Historically, homes and businesses communicated with the rest of the world using telephone lines, the endpoints of which could be standard telephones, fax machines, modems to support computer communications, and voice/video devices for multimedia communication. Regardless of the endpoint device being used, the device would connect to the public switched telephone network to communicate with some remote endpoint. Security primarily consisted of stopping attackers from making calls without paying for them or severing connections. Because all telephone line connections were leased from a communication company, attackers making unauthorized calls could cost an organization large amounts of money.

As LANs and the Internet became more commonplace, organizations began to replace traditional phone systems with devices that use IP networks to communicate. Many of today's businesses use their IP networks for voice and video calls, the cost of which can be reduced by replacing traditional phone

lines with Voice over IP (VoIP) software and services. Though VoIP is not free, it can be far less costly than leasing traditional phone lines.

The Session Initiation Protocol (SIP) establishes and manages connections between endpoints by setting the stage for a connection that VoIP or other media-related protocols can use to support audio and video calls. Although using an existing network for SIP/VoIP traffic can reduce phone line costs, doing so has several drawbacks: increases in traffic, service costs, and risk. Adding voice and video to an existing network increases that network's usage and can cause performance problems if the available bandwidth is insufficient to handle the traffic; implementing SIP/VoIP likely requires software and agreements with external service providers to carry the content outside the local environment and interface with the traditional telephone system; and, finally, SIP/VoIP traffic is subject to the same network attacks as any other network traffic.

Securing voice and video communications is essentially just like securing any other network traffic. However, there are a few steps that each organization should take to keep SIP/VoIP communications secure. Following are some of the best practices for securing SIP/VoIP:

- Patch all SIP/VoIP software and network component firmware.
- Use VLANs to separate voice and video from other network use (i.e., workstations and printers).
- Enforce encrypted VPN use for all remote access (including SIP/VoIP).
- Require end-to-end encryption for all voice or video calls using TLS or Secure Real-Time Transport Protocol (SRTP).
- Enforce strong authentication for all network users.
- Use firewalls to protect all SIP/VoIP devices and services.
- Harden all SIP/VoIP devices and software.

Wireless Networks

Wireless networks have become very popular for connecting devices within the home and office, such as laptops; desktops; smartphones; and many other devices, including the growing number of Internet of Things (IoT) devices. Wireless networking allows users to work from any location in the building without worrying about finding a place to plug in a network cable.

Configuring a wireless network is quite easy and inexpensive. The question becomes, what does wireless technology do to the security of the network? If it is so easy for personnel to connect to the network, does that mean that others can connect as well?

Setting up a secure wireless network—at least one as secure as any wired network—is possible with properly configured strong encryption. However, it takes careful planning, execution, and testing. This section covers wireless networking technology and how to configure and secure wireless networks.

Wireless Access Points

A **wireless access point (WAP)** is a radio, sending and receiving networking information over the air between wireless devices and the wired network. Anyone with a wireless device who is within radio range of a WAP can communicate with and attempt to connect to the network via the device.

Attackers who want to undermine the security of a wireless network understand that wireless networks extend the range of an organization's network beyond its walls. While you can easily control physical access to a wired network, walls and fences do not stop wireless signals. Therefore, wireless networks without proper security present an easy target for attackers who want to connect to them. Moreover, attackers know that it is much easier to eavesdrop on a wireless than a wired network. Anyone within radio range of a network can easily capture all the data sent on that network, and, if the data is unencrypted, that organization is fair game for an attack.

Wireless Network Security Controls

Fortunately, you can do quite a bit to secure a wireless network with wireless network security controls, which are the subject of this section. The most important security control is wireless encryption to prevent eavesdropping. Other techniques that provide added security include disabling service set identifier (SSID) broadcasting, implementing **MAC address filtering**, and adding strong authentication to the wireless network.

VPN over Wireless

One of the most secure ways to implement secure wireless networks is to use VPNs for all wireless connections. Access to a VPN for internal users is easy to manage, whereas guest access is more difficult. One common solution is to create at least two separate wireless networks—one network for internal users who require VPN access and greater connectivity into the internal network and one network for guests that does not allow VPN access and has very limited connectivity to the internal network.

Wireless Encryption

Encryption is the single most important thing you can do to secure a wireless network because encryption makes an outsider's viewing information traveling over that network impossible, whereas, without encryption, all wireless users' activities are visible to anyone who comes within radio range of the network. Without encryption, an attacker could, with an inexpensive antenna attached to a standard laptop, sit in the parking lot of an organization's building and monitor everything happening on its wireless network.

Another consideration in using encryption is that it must be strong, unlike the basic encryption provided by the **Wired Equivalent Privacy (WEP)** standard, which was developed in the early days of wireless networking. WEP relies on the RC4 encryption algorithm, which was created by Ron Rivest for RSA in the late 1980s. Since its release, security analysts have discovered that it has significant flaws that make it insecure. With software freely available on the Internet, it is simple to break the encryption on a WEP network in a matter of seconds. In fact, using WEP on a wireless network is probably worse than using no encryption at all because it provides a false sense of security. People feel they are safe because their wireless network

encrypts traffic. What they do not realize is that they're using the equivalent of a Cap'n Crunch® decoder ring to protect their data.

LEAP and PEAP

To help manage wireless keys and authentication, Cisco Systems developed the Lightweight Extensible Authentication Protocol (LEAP), which could use either WEP or Temporal Key Integrity Protocol (TKIP) for setting up secure connections. Because WEP weaknesses were well known, TKIP emerged as a stopgap substitute for WEP that would operate on existing hardware that supported only WEP.

Later, Cisco, Microsoft, and RSA joined together to address LEAP's weaknesses, and from that collaboration came the Protected Extensible Authentication Protocol (PEAP), which differs from LEAP in that it does require a certificate on the server.

Fortunately, several alternatives were developed to address WEP's weaknesses. One of these alternatives is the Counter Mode Cipher Block Chaining Message Authentication Code Protocol (CCMP), which is an encryption protocol that implements the IEEE 802.11i standard and provides enhanced security using the Counter Mode of the Advanced Encryption Standard (AES). In addition to CCMP, the **Wi-Fi Protected Access (WPA)** standard, which became available in 2003, uses strong AES encryption to protect data on networks and does not have the same vulnerabilities that were discovered in WEP. WPA refers to the draft of the IEEE 802.11i security standard, which was intended to be an intermediate solution to WEP's vulnerabilities. To take the place of the temporary WPA, a more secure standard, WPA2 (official name 802.11i-2004), was made available in 2004, followed in 2018 by the latest and most secure standard, WPA3. WPA3 can operate in WPA-Enterprise mode, using AES-256 in GCM mode, and WPA3-Personal mode, using AES-128 in CCM mode. As of July 2020, WPA3 is mandatory for new Wi-Fi device certifications issued by the Wi-Fi Alliance.

All three standards, WPA, WPA2, and WPA3, are easy to configure. In their basic form, they require entering a shared secret key into the network

configuration of every computer on the network. In more advanced forms, you can replace the shared secret key by giving each user a unique username and password, which can be identical to the user's normal credentials by using a central authentication server, such as a Remote Authentication Dial-In User Service (RADIUS) server. RADIUS was introduced in 1991 and quickly became a popular protocol used for managing remote user connections because it provides a central method to manage authorization, authentication, and accounting (AAA) services. DIAMETER, its successor, was introduced in 1998 and has recently become more popular than RADIUS for handling wireless remote connections because it has the ability to address more mobility issues. For example, DIAMETER includes better roaming support and can use TCP or Stream Control Transmission Protocol (SCTP).

TIP

Disabling SSID broadcast provides a small degree of protection, but this technique is not foolproof. In fact, a skilled attacker can easily discover the presence of a network by using freely available software tools. Using this technique simply means you do not advertise the presence of the network, hoping to avoid the casual attacker's interest.

SSID Broadcast

By default, wireless networks broadcast their presence to the public by sending out announcements containing the network's SSID, which is the network's public name. For instance, when you boot up in a coffee shop with Wi-Fi, your computer shows you a list of the available wireless networks along with their SSIDs.

You can stop a network from announcing itself by disabling SSID broadcast on the wireless access points. If you disable SSID broadcast, users wanting to connect to that network will need to know it is there and provide its name themselves. Using this technique is fine if only regular users connect to the network, such as in a corporate environment, but will not work well if guests are allowed to access the network.

MAC Address Filtering

WAPs also enable the application of MAC address filters to control which computers can connect to a network. With this technology, the WAP is provided with a list of acceptable MAC addresses, which means that only approved computers are allowed access to connect to the network.

The major disadvantage of MAC address filtering is that it is very complicated to maintain, which limits its usefulness to no more than a handful of computers on the network. More than that, and it quickly becomes a major challenge to update the list of acceptable MAC addresses. As an example, imagine if you worked for an organization with 20,000 users. In such an organization, it would not be unusual to see 100 new computers on the network every week in addition to 100 dropping off the network as you replace them. Can you imagine trying to update 200 MAC addresses every week? Use MAC address filtering in cases where it makes sense.

Additional Wireless Security Techniques

In addition to the preceding suggestions, selecting the right hardware and placing that hardware in the right position can have a noticeable impact on a network's security. In particular, pay attention to these aspects of wireless hardware management:

- **Antenna types**—Wireless device antennas can have a large impact on the device's area of coverage and how it transmits and receives, so choosing the right antenna, based on an organization's use, is important. Generally, external antennas can reach farther than internal antennas, and all antennas can be omnidirectional (all directions), semidirectional (limited direction), or highly directional (focused direction).
- **Antenna placement**—Where antennas are placed determines who has access to the wireless network. For example, placing an omnidirectional antenna near an external wall will likely make the wireless network available to people outside the building.
- **Power-level controls**—The power a wireless device uses can be changed from the configuration settings. Lowering the power settings from the default will reduce the area the device covers, which can be helpful when attempting to limit the visibility of wireless networks.

- **Captive portals**—A captive portal is a webpage to which all new connections are directed until the connection is authenticated. The most common use of a captive portal is to provide a logon page for wireless networks.
- **Site surveys**—One of the most important nontechnical aspects to securing wireless networks is to survey the site, which includes examining the physical area the wireless network will serve. Using facility floor plans can help determine the best placement for wireless devices before they are physically placed.

Although no network is totally secure, the best way to make an IT infrastructure as secure as possible is to ensure that an attacker must compromise several controls to get to the data, and that means putting the right security controls in place. Always assume that a savvy attacker will be able to compromise one or more of the controls that are in place, which makes it necessary to never rely on a single control and to always use layered controls.

WARNING

MAC address filtering is another weak security mechanism. In a type of address spoofing, using free tools, attackers can easily discover an active MAC address on a network and then change their network interface to use the discovered valid MAC address.

CHAPTER SUMMARY

In this chapter, you learned about the Open Systems Interconnection (OSI) Reference Model and how it serves as an example of how you can build and use a network and its resources. You learned about Network Layer protocols, including an overview of TCP/IP, as well as some basic tools for network security. Finally, you learned how wireless networks work and what threats they pose to the security of an organization.

KEY CONCEPTS AND TERMS

Application proxy firewall
Border firewall
Demilitarized zone (DMZ)
Dynamic Host Configuration Protocol (DHCP)
Extensible Authentication Protocol (EAP)
Firewall
Hub
ICMP echo request
Internet Control Message Protocol (ICMP)
Internet Protocol Security (IPSec)
IP address
IPv4 address
IPv6 address
MAC address filter
Network access control (NAC)
Network address translation (NAT)
Network port
Open Systems Interconnection (OSI) Reference Model
Packet-filtering firewall
Protocol
Router
Secure Sockets Layer (SSL)/Transport Layer Security (TLS)
Stateful inspection firewall
Subnet
Switch
Wi-Fi Protected Access (WPA)
Wired Equivalent Privacy (WEP)
Wireless access point (WAP)

CHAPTER 5 ASSESSMENT

1. The basic model for how you can build and use a network and its resources is known as the _____.

   A. Dynamic Host Configuration Protocol (DHCP) model

   B. International Organization for Standardization (ISO) model

   C. Open Systems Interconnection (OSI) Reference Model

   D. None of the above

2. The basic job of a _____ is to enforce an access control policy at the border of a network.

   A. Firewall

   B. Router

   C. Switch

   D. Access point

3. A _____ is a critical element in every corporate network today, allowing access to an organization's resources from almost anywhere in the world.

   A. Local area network (LAN)

   B. Wide area network (WAN)

   C. Dynamic Host Configuration Protocol (DHCP)

   D. None of the above

4. A secure virtual private network (VPN) creates an authenticated and encrypted channel across some form of public network.

   A. True

   B. False

5. _____ is a suite of protocols that was developed by the Department of Defense to provide a highly reliable and fault-tolerant network infrastructure.

A. DHCP

B. VPN

C. IPSec

D. TCP/IP

6. A ___ is a device that interconnects two or more networks and selectively interchanges packets of data between them.
7. Which simple network device helps to increase network performance by using the MAC address to send network traffic only to its intended destination?

   A. Hub

   B. Switch

   C. Router

   D. Gateway

8. The three basic types of firewalls are packet filtering, application proxy, and stateful inspection.

   A. True

   B. False

9. What technology is the most secure way to encrypt wireless communications?

   A. TCP

   B. WEP

   C. WPA

   D. UDP

10. IP addresses are assigned to computers by the manufacturer.

    A. True

    B. False

11. Which VPN technology allows users to initiate connections over the web?

    A. SSL/TLS

B. PPTP

C. IPSec

D. ICMP

12. What layer of the OSI Reference Model is most commonly responsible for encryption?

A. Application

B. Presentation

C. Session

D. Transport

13. DHCP provides systems with their MAC addresses.

A. True

B. False

14. What firewall topology supports the implementation of a DMZ?

A. Bastion host

B. Multilayered firewall

C. Border firewall

D. Screened subnet

15. What technology allows you to hide the private IPv4 address of a system from the Internet?

A. SSL

B. RADIUS

C. PPTP

D. NAT

CHAPTER 6
Access Controls

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ACCESS CONTROLS are methods used to restrict or allow access to certain items, such as automobiles, homes, office buildings, computers, and even a smartphone. Your first experience with access controls might have been as a child when you locked a sibling out of your room or used a locker at school. Similarly, the key to your car fits *only your car* so that only you can unlock and start it. The same is true of your house or apartment. You might be one of the many people who also use a special code to unlock your smartphone or tablet so no one can unlock the secured device without the code. Or maybe you cannot view certain channels on your television or even retrieve your voicemail messages without a security code.

Thus, access control is the process of protecting resources so that they are used only by those allowed to use them in order to protect resources from unauthorized use or a threat. Just as the lock-and-key systems for a house or car are access controls, so are the personal identification numbers (PINs) on a bank or credit card.

Businesses use access controls to manage what their personnel can and cannot do, including who users (people or computer processes) are, what users can do, which resources they can interact with, and what operations they can perform. Access can be granted to physical assets, such as buildings or rooms, or to computer systems and data. To achieve this goal, access control systems use several methods, including passwords, hardware tokens, biometrics, and certificates.

Chapter 6 Topics

This chapter covers the following topics and concepts:

- What the four parts of access control are

- What the two types of access control are
- How to define an authorization policy
- What identification methods and guidelines are
- What authentication processes and requirements are
- How recognition and authentication differ
- What accountability policies and procedures are
- What formal models of access control are
- What threats there are to access controls
- What some effects of access control violations are
- What centralized and decentralized access controls are

Chapter 6 Goals

When you complete this chapter, you will be able to:

- Define access control concepts and technologies
- Describe the formal models of access control
- Describe how identity is managed by access control
- Contrast recognition and authentication
- Develop and maintain system access controls

Four-Part Access Control

Before an asset can be protected, the entity wishing to protect the asset must know some information about the intended user and how that user should be allowed to interact with the asset. The four parts of **access control** provide this information along with the assurance that access is sufficiently managed:

- **Identification**—Who is asking to access the asset?
- **Authentication**—Are the requestors' identities verified to be the claimed identities (i.e., are the users who they claim to be)?
- **Authorization**—What, exactly, can the requestors access? And what can they do?
- **Accountability**—How can actions be traced to an individual? It is important to be able to identify a person who accesses or makes changes to data or systems for later reporting and research purposes, which is a process known as *accountability*.

The preceding four parts are divided into two phases:

- **Policy definition phase**—The authorization definition process operates in this phase to determine who has access and what systems or resources they can use.
- **Policy enforcement phase**—The identification, authentication, authorization execution, and accountability processes operate in this phase to grant or reject requests for access based on the authorizations defined in the first phase.

Two Types of Access Controls

Access controls generally fall into one of two categories:

- **Physical access controls**—Control access to physical resources, such as buildings, parking lots, and protected areas. For example, a key to the door of an office controls the *physical* access to that office.
- **Logical access controls**—Control access to a computer system or network. As an example, a username and password allow personnel to use an organization's computer system and network resources.

NOTE

Sometimes the difference between *access control* and *access controls* can be confusing. Just remember that *access control* is something that is done to protect resources, whereas the way to protect resources from unauthorized access is by using different types of *access controls*.

Physical Access Control

An organization's facilities manager is often responsible for **physical access control**, meaning access to *physical* resources, which might be enabled through a security card (also known as a **smart card**) programmed with an employee's ID number. Employees might need to swipe this card through a card reader to open a gate to the parking lot, send an elevator to the appropriate floor, or unlock a door leading to an office. The organization's authorization policy is what determines who is allowed physical access and to what places. Without this authorization, here, in the form of a security card, people would not get past the front gate. Moreover, if an organization shares its office building with other organizations, authorized personnel might even have a second card that grants access into the building after hours.

Logical Access Control

Security administrators use **logical access controls** to decide who can get into a system and what tasks they can perform, as does a system manager, to influence how staff personnel use a system. Examples of system controls for a human resources (HR) system include the following:

- **Deciding which users can log into a system**—HR employees may be the only employees who are allowed to reach sensitive information stored on an HR server.
- **Monitoring what the user does in that system**—Certain HR employees might be allowed to only view documents, whereas other HR employees might be able to both view and edit those documents.
- **Restraining or influencing the user's behavior on that system**—An HR staffer who repeatedly tries to view restricted information might be denied access to the entire system.

The Security Kernel

The **security kernel** is the central part of a computing environment's hardware, software, and firmware that enforces access control for computer systems. It provides a central point of access control, implements the reference monitor concept, and mediates all access requests and permits access only when the appropriate rules or conditions are met. Following are the steps the security kernel takes in enforcing access control:

1. The subject (a user) requests access to an object (an asset). The security kernel then intercepts the request.
2. The security kernel refers to its rules base, also known as the *security kernel database*. It uses these rules in this database to determine access rights, which are set according to the policies the organization has defined.
3. The kernel allows or denies access based on the defined access rules. All access requests handled by the system are logged for later tracking and analysis.

FIGURE 6-1 shows a request for access coming from the subject to a specific object, in this case, a file, and then the reference monitor intercepting the access request. The access is then granted according to the rules in the security kernel database. This database might be an access control list (ACL), a directory, or another repository of access permissions. If the rules permit the access request, the reference monitor permits access and creates a log entry.

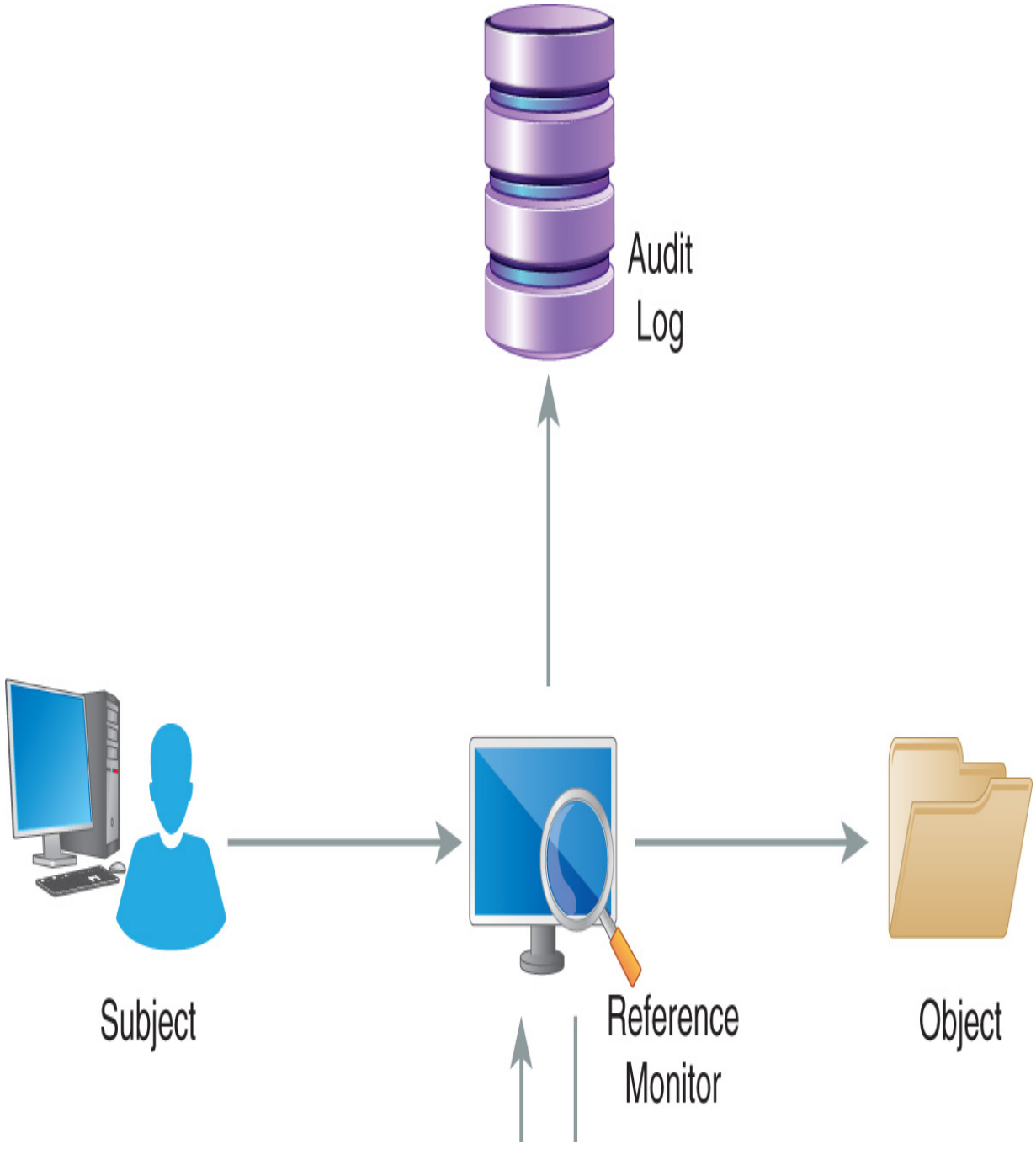


FIGURE 6-1 Enforcing access control.

It is easy to see that the overall security of any system's access control depends on the security of the operating system. Most of the popular computer operating systems (e.g., Windows®, Linux®/UNIX®, and macOS®) provide extensive security features, which allow administrators to create very secure systems. However, the popular operating systems for many mobile devices (e.g., Android™ and iOS®) lack some of these security features, which is justified by the argument that mobile devices do not need the same level of security features as servers or full-featured client computers. However, as mobile devices become more powerful and ubiquitous, the need for tighter security increases. Furthermore, the rapid rise in the number of Internet of Things (IoT) devices makes it clear that even unattended devices, such as doorbells and refrigerators, are targets for attackers and need stronger security as well. Even though most operating systems provide extensive security guarantees, some computing environments need even more, such as systems that handle extremely sensitive information (e.g., classified information on government servers); therefore, several operating systems have included supplemental controls to address the additional security needs of such systems. These operating systems, referred to as *trusted operating systems (TOS)*, provide features that satisfy specific government requirements for security. One of the most widely used set of criteria for TOS design is the Common Criteria, which you will read about later in this chapter.

Access Control Policies

An **access control policy** is a set of rules that allows a specific group of users to perform a specific set of actions on a specific set of resources. If users are not authorized, they do not have access to system functions or system resources. Access control policies are important to reduce and control security risks, and both automated processes and humans must adhere to them.

To manage access control policies well, you must understand their four central components:

- **Users**—Users are the people who use the system or processes that perform some service for other people or processes. A more general term for users is *subjects*.
- **Resources**—Resources are the protected objects in the system. They can be accessed only by authorized subjects and used only in authorized ways.
- **Actions**—Activities that authorized users can perform on the resources.
- **Relationships**—Relationships are optional conditions that exist between users and resources. They are permissions granted to an authorized user, such as *read, write, and execute*.

TIP

Many discussions of access control concepts use the terms *subject* for the user and *object* for the resource. You may also see the term *request*, which refers to an access action a subject tries to carry out.

Authorization Policies

The first step toward controlling access is to create a policy that defines authorization rules. **Authorization** is the process of deciding who has access to which computer and network resources. In most organizations, authorization is based on job roles, background screening, and any government requirements. These conditions or policies are decided primarily by either a group membership policy or an authority-level policy.

The most detailed authorization policy is based on individual users. In this type of policy, each user has specific assigned privileges, which allow administrators to define approved resource access at a very detailed level. However, maintaining a user-based authentication approach is very difficult because it requires a lot of administration time to stay current.

In a group membership policy, authorization is defined by what group(s) users are in, which reduces the administrator's workload by grouping similar users together. For example, perhaps only the security cards of members of the IT department give access to the room where computer equipment is stored. If personnel are not members of this IT group, their security card does not let them enter this room to retrieve a new monitor. If they want to access the computer equipment storage room, they must first contact the IT department, which likely assigns a member of the IT group to help them.

In an authority-level policy, users need a higher degree of authority to access certain resources. For example, perhaps only a senior-level member of the IT group has permission to enter the room that houses servers, which makes sense, because servers are often more valuable than computer monitors.

Methods and Guidelines for Identification

Once you define authorization rules in an authorization policy, you can enforce the rules. Each time a user requests access to a resource, the access controls either grant or deny access based on the authorization policy.

The first step in enforcing an authorization policy is to determine the identity of the subject, which is a process called **identification**. This process allows a subject, which can be a user, a process, or some other entity, to claim to be a specific identity. Several methods are commonly used to identify subjects, and the chosen method depends on the security requirements and capabilities of the computing environment. The next section covers various methods and guidelines for how a subject identifies itself to a system.

Identification Methods

The most common method to identify a user to a system is a username, which can be in the form of a user ID, an account number, or some other assigned identifier. Some applications identify a user using a smart card, which often looks like a plastic credit card. Smart cards make it easy for subjects to provide complex identification credentials without having to remember them. Just as you might slide your credit card through an electronic card reader to make a purchase, you can swipe a smart card through card readers, which grant access to such things as parking facilities, buildings, and rooms.

NOTE

The U.S. Customs and Border Protection (CBP) program uses various types of biometrics to identify authorized members of the program. It defines several programs that preauthorize frequent travelers to bypass regular customs lines and use faster automated kiosks, two of which are the NEXUS kiosks at select U.S. and Canadian border crossings, which

use retina scans to identify users, and the Global Entry kiosks at many international airports in the United States, which use a combination of fingerprint scanners and retina scanners to identify users.

Another access control method for identifying subjects is **biometrics**, which can be used to recognize humans based on one or more physical or behavioral traits or to validate identities. Examples of biometrics include fingerprints, face or voice recognition, DNA matching, handwriting, retina scans, and even the way a person types.

Identification Guidelines

To ensure that all actions carried out in a computer system can be associated with a specific user, each user must have a unique identifier. The guarantee that every action is associated with a unique identity is called *nonrepudiation*, which means that it is important for each user to have a unique user account. An account policy should prohibit generic accounts and user account sharing and include unique identifiers (IDs) for distinguishing between multiple users with the same name. The process of associating an action with a user for later reporting or analysis is called *accounting*, which, when done properly, must include nonrepudiation. Moreover, the data used to identify subjects should be kept current and closely monitored; the IDs of users who leave the organization or who are inactive for an extended time, disabled; and standard naming conventions, which should not relate to job functions, applied. The process for issuing, managing, and retiring IDs should be documented and secure.

Processes and Requirements for Authentication

So far in this chapter, you have learned about methods to define authorization rules and identify users. The next step is authentication. In this part of access control, users validate, or prove, the identity they claimed during identification. **Authentication** answers the question, are subjects who they claim to be? Because anyone can claim to be any identity, authentication verifies that the subject requesting access is really the claimed identity (authentic) and the same subject who has been granted access. Without authentication, you could never really know if subjects are who they say claim to be.

Authentication Types

Following are the seven types of authentication:

- **Knowledge**—Something you (the user) know, such as a password, passphrase, or PIN.
- **Ownership**—Something you have, such as a smart card, key, badge, or token.
- **Characteristics**—Some attribute that is unique to you, such as your fingerprints, retina, or signature. Since the characteristics involved are often physical, this type of authentication is sometimes defined as *something you are*.
- **Action/performance**—Some action that you can perform, such as reproducing a signature, sometimes defined as *something you can do.*
- **Behavior**—Some observable trait or behavior that is unique to you, sometimes defined as *something you exhibit.*
- **Location**—Somewhere you are, such as your physical location when attempting to access a resource.
- **Relationship**—A trusted individual with whom you have a relationship, encouraging trust by association, sometimes defined as *someone you know*.

WARNING

A combination of username and password is considered single-factor authentication even though it appears to require two steps. The username satisfies the identification step, and the password satisfies the authentication step. Using a single type of authentication may not be adequate for access to more sensitive systems, applications, or data, in which case, two-factor or multifactor authentication might be required, such as swiping a card (something you have) to enter a building and then typing a PIN (something you know) to ensure the security of a valuable resource.

TIP

The classic authentication discussion limits the authentication types to only three: Type 1 (what you know), Type 2 (what you have), and Type 3 (what you are). Because we are covering the current authentication environment, we will cover the more recent methods, as well as the "core" methods.

The use of controls from only one category is known as *single-factor authentication*. However, because each type of authentication can easily be compromised on its own, systems that contain sensitive or critical information should use at least two authentication types, which is called *two-factor authentication (2FA)*, or **multifactor authentication (MFA)**, to provide a higher level of security than using only one.

Authentication by Knowledge

Authentication by knowledge is based on something you (the user) know, such as a password, passphrase, or PIN. Passwords are the oldest and most

common method of authentication for computer systems as well as being the weakest; therefore, they should not be used alone to protect valuable resources. Moreover, as the value of a resource increases, so should the strength of the access controls protecting it, which makes MFA a requirement for protecting access to valuable resources.

Because of their simplicity and popularity, passwords are common targets of cyberattacks. The most often used are brute-force and dictionary attacks, which can easily crack weak passwords, such as those that are very short or contain dictionary words.

- A brute-force attack involves trying every possible combination of characters, whereas modern password crackers take a more effective approach. First, they measure the entropy (i.e., a measure of randomness) of characters and then test low-entropy, then medium-entropy, and finally high-entropy words.
- A dictionary password attack works by hashing all the words in a list of possible passwords (often supplemented with suffixes such as 01, 02, 4u, and so on) and then comparing the hashed value with the system password file to discover a match. The prepared list of possible passwords is called a dictionary. Hackers are familiar with all the usual tricks, such as spelling a name backward or simple substitution of characters (e.g., 3 for e, 0 for o, $ for s, and so on).
- Because most systems store a hash of the password, attackers first precompute these dictionary words and build a table, known as a rainbow table. Then, they look up the stored hashed version of the password in the table to discover the word that generated it. Rainbow tables are widely available. For example, AccessData's forensic investigator's tool, known as the Forensic Toolkit® (FTK®), features a rainbow table with a million words, which, according to FTK's website, detects 28 percent of user passwords.

TIP

A shorter password life span means more protection for the user because it lowers the chance that an attacker can compromise and use the password before it expires. To create stronger password controls for users, consider a 30-day password-change policy.

Password Account Policies.

In addition to encouraging password best practices, an account policy should include clear password requirements. Following is a list of suggested account policy password requirements (the specifics of these items should be customized for a particular organization).

- Complexity
  - Passwords must contain at least eight alphanumeric characters.
  - Passwords must contain a combination of uppercase and lowercase letters and numbers.
  - Passwords must contain at least one special character within the first seven characters of the password.
  - Passwords must contain a nonnumeric letter or symbol in the first and last character positions.
  - Passwords must *not* contain the username.
  - Passwords must never include the name of the user or the names of any close friends or relatives.
  - Passwords must never use an employee's ID number, Social Security number, birth date, telephone number, or any personal information that can easily be guessed.
  - Passwords must never include common words from an English dictionary (or a dictionary of another language with which the user is familiar).
  - Passwords must never employ commonly used proper names, including the name of any fictional character or place.
  - Passwords must never contain any simple pattern of letters or numbers, such as *qwertyxx*.

- Expiration. Passwords that protect sensitive data expire every 90 days (30 days for highly sensitive accounts) and must be changed.
- Recovery. Forgotten passwords can be recovered after providing alternate authentication credentials via the organization's internal password recovery utility.
- Disablement. User accounts will be disabled immediately when a user is no longer associated with the organization or no longer requires provided access.
- History. Password history is stored, and users' passwords cannot be changed to any of the 10 previous passwords that they have used.

Password Best Practices

One of the most visible security policies is the user account policy, a policy that each user must encounter. A good user account policy sets clear requirements for user accounts and passwords, and, as you have already seen, it should prohibit generic user accounts. An account policy should also include password best practices:

- **Create strong passwords**—Your password must be complex enough to be unlikely to be compromised and must meet minimum length requirements. You should never use a word that appears in the dictionary as your password, nor should it be based on personal information. Hackers have easy access to powerful password-cracking tools that use extensive word and name dictionaries, so to make passwords more secure use words that do not make any sense but are easy to remember. For example, you might create a password using letters from the first words of a poem or song, or you might substitute obscure characters, such as asterisks (*), dollar signs ($), "at" symbols (@), brackets ({}), or mathematical symbols (+) for letters. Passwords such as these can be extremely difficult to guess or crack. Remember, cracking tools check for simple tricks, such as words spelled backward or simple substitutions for certain characters (for example, where *mouse* becomes m0us3).

- **Do not store a written copy of the password unless absolutely necessary**—If you must store a written copy, keep it in a secure place, or, alternatively, write down a hint for your password instead of the actual password. Destroy any written copies when they are no longer needed. Better yet, use a password manager, such as LastPass, Keeper, or Dashlane, to securely store your passwords.
- **Never share your passwords with anyone**—Even if it is someone you trust, your password should be kept private.
- **Use different passwords for different important user accounts**—Using a single password for all your accounts is like using a single key for your car, your house, your mailbox, and your safety deposit box. If you lose the key, an attacker has access to everything. When you use different passwords for different systems, then, if one of your passwords is stolen, only that one system is compromised, and the others are still safe. Moreover, avoid using passwords that are like one another, for example, passwords that use the names of your children. If you use the same or similar passwords for more than one system, intruders who obtain one of your passwords can more easily figure out the rest.
- **If you think a password has been compromised, change it immediately**—Moreover, the first time you use them, change passwords that are assigned to you. Ideally, you should change passwords at least once every 30 days.
- **Be careful when saving passwords on computers**—Some dialog boxes (such as those for remote access and other telephone connections) present options to save or remember passwords. Selecting these options poses a potential security threat because the password is automatically listed when someone opens the dialog box.

Passphrase Usage.

A passphrase is somewhat different from a password in that it is longer and generally harder to guess and therefore is considered more secure,

particularly against dictionary and brute-force attacks because it usually contains more than one word. Most often, passphrases are used for public and private key authentication. Users use a passphrase that is known only to them to unlock a private key that gives them access to information. A system can be programmed to automatically convert the passphrase to a password according to an algorithm; however, in most cases, the user does the conversion.

NOTE

Reusing a password for resources that are not considered critical is okay, for example, to access articles on an online news site. However, do not use that same password for any logons for critical resources. A good rule of thumb is to use weaker or duplicate passwords only for resources that store no personal or financial information.

Account Lockout Policies.

Many systems are configured to disable a user ID after a certain number of consecutive failed logon attempts, often three to five attempts. The number of failed logon attempts that trigger an account action is called the threshold. The user may be locked out for a few minutes, a few hours, or until the account is reset by a security administrator. This practice helps guard against attacks in which the attackers make several attempts to guess a password, but it also enables an intruder to lock out users, which is a form of denial of service (DoS) attack, by entering groups of incorrect passwords.

FYI

Unless an organization uses an automated password-reset process, the help-desk personnel will likely find that password-reset requests are the most common type of request they receive. When help-desk personnel receive such requests, they should require users to provide information

that verifies their identity, such as a driver's license or employee ID. If the request is not made in person, help-desk personnel should use a form of questioning that verifies users' identities, for example, "What is your mother's maiden name?" A lack of strong identity validation can allow an attacker to request a password change for any user's account and then, after changing the password, to access the account at will.

Although auditing logon events can be helpful for intrusion detection efforts, be careful. Failure auditing can also expose systems to a DoS attack, which can occur in one of two ways:

- Attackers fill the security log, possibly causing a system crash or preventing other users from logging on.
- Attackers cause events to be overwritten, which they do by continuously attempting to log on to the network with incorrect usernames or passwords. Purposely overwriting audit events can effectively erase evidence of attack activity.

A restrictive account-lockout policy increases the probability of preventing an attack on the organization, but a stringent policy can unintentionally lock out authorized users, which can be frustrating and costly. When you apply an account-lockout policy, set the threshold to a high enough number that authorized users are not locked out because of mistyped passwords.

Audit Logon Events.

One method of keeping track of who is accessing a computing environment is to audit logon events, a practice that provides a record of when every user logs on or off a computer. If an unauthorized user steals a user's password and logs on to a computer, you can determine when that security breach occurred. When you audit failure events in the logon event category (also known as *failure auditing*), you can see whether the failure event was due to unauthorized users or attackers attempting to log on to a computer or system, the latter of which is an example of intrusion detection.

Authentication by Ownership

Authentication by ownership is based on something you have, such as a smart card, a key, a badge, or either a synchronous or asynchronous **token**.

Synchronous Tokens.

Synchronous tokens can be either a physical device, such as a system that uses continuous, time-based, or event-based authentication, or software, such as an authenticator app. All synchronous tokens use an algorithm at both the authentication server and the device to calculate a number, which is then displayed on the device's screen. Users then enter the number as a logon authenticator, just as they would enter a password.

With a time-based synchronization system, the current time is used as the input value. The token generates a new dynamic password (usually every minute) that is displayed in the window of the token. To gain access, the password is entered with the user's PIN at the workstation, and no token keyboard is required. This system necessitates that the clock in the token remain in sync with the clock in the authentication server. Should the clocks drift out of sync, the server can search three or four minutes on each side of the time to detect an offset, but, if the difference becomes too great, the clocks must be resynchronized.

NOTE

Synchronous tokens can be used in proximity devices that cause both the PIN and the password to be entered automatically.

An event-based synchronization system avoids the time-synchronization problem by increasing the value of a counter with each use. The counter is the input value. Users press a button to generate a one-time password and then enter this password with their PIN at the workstation to gain access. One common problem with event-based synchronization systems, though, is when a user creates a password using the token but does not use the password to

log on, which causes the counter in the server and the counter in the token to become out of sync.

The third type of synchronous token is continuous authentication, which is used by systems that continuously validate the user's identity, something that is often done with proximity cards or other devices that continuously communicate with the access control system. With continuous authentication, if the user walks away from the desktop and steps outside the range of the access control detector, the system locks the desktop.

Asynchronous Tokens.

An asynchronous token device uses challenge–response technology that involves a dialogue between the authentication server and the remote entity that it is trying to authenticate, a process that requires a numeric keyboard. Initial implementations of asynchronous tokens required a physical device that looked like a credit card–sized calculator, but later solutions relied on smaller devices the size of a key fob. With this asynchronous token, the authentication server issues a challenge number, which users enter, after which the token software computes a response to the value provided by the authentication server. Users then reply to the server with the value displayed on the token. Many of these systems also protect the token from misuse by requiring the user to enter a PIN along with the initial challenge value.

FIGURE 6-2 shows an asynchronous token challenge–response process.

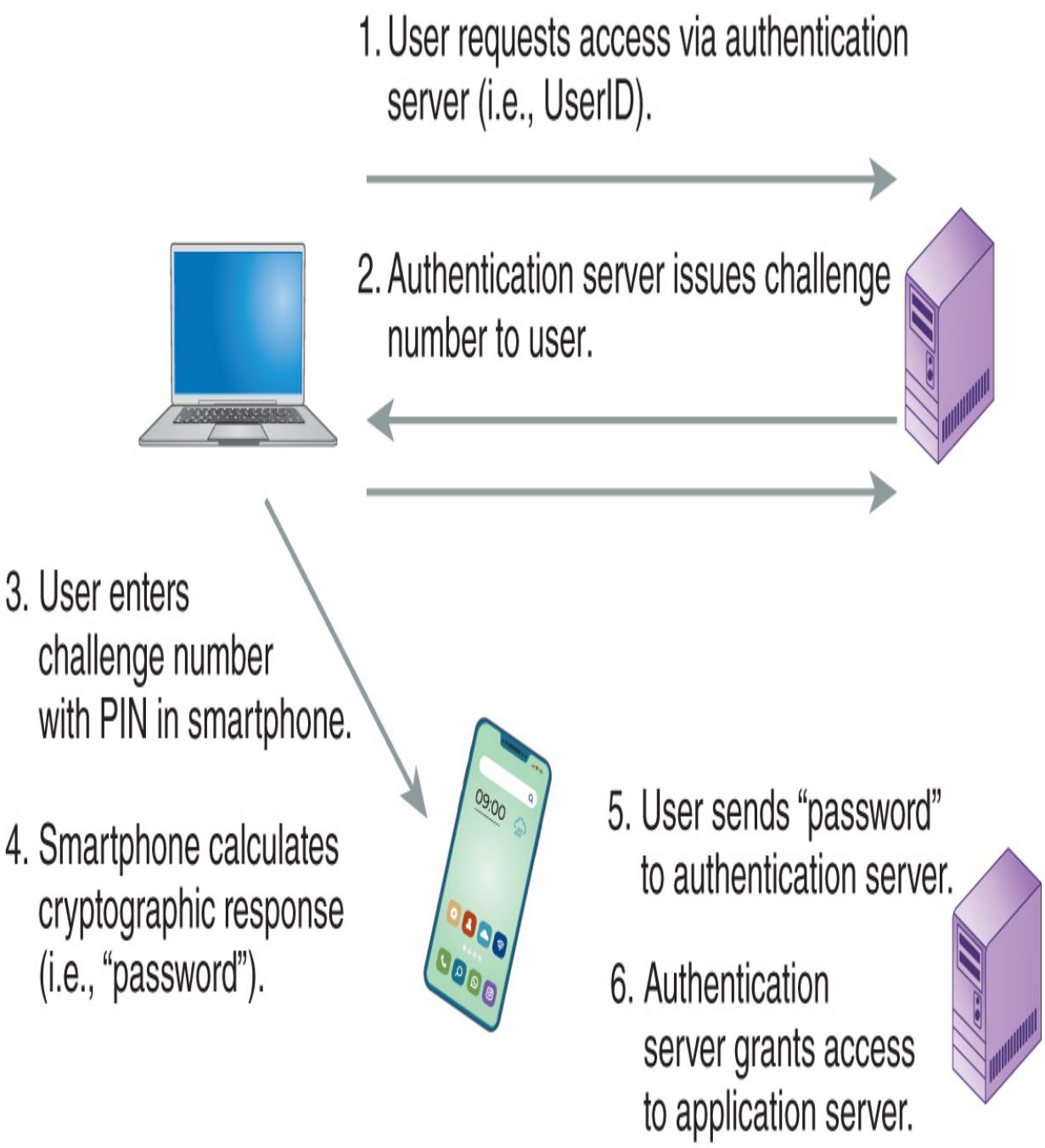

1. User requests access via authentication server (i.e., UserID).
2. Authentication server issues challenge number to user.
3. User enters challenge number with PIN in smartphone.
4. Smartphone calculates cryptographic response (i.e., "password").
5. User sends "password" to authentication server.
6. Authentication server grants access to application server.
09:00

FIGURE 6-2 Asynchronous token challenge–response.

1. User requests access via authentication server (i.e., UserID).
2. Authentication server issues challenge number to user.
3. User enters challenge number with PIN in smartphone.
4. Smartphone calculates cryptographic response (i.e., "password").
5. User sends "password" to authentication server.

6. Authentication server grants access to application server.

Here are the steps in an asynchronous challenge–response session:

1. The user initiates a logon request.
2. The authentication server provides a challenge (a random number that is the input value) to the user.
3. The user enters the challenge received from the server and a secret PIN known only to the user into the calculation device (a credit card–sized calculator or a software program on a computer or smartphone).
4. The token (or program) generates the response (the password) to the challenge, which appears in the window of the token.
5. The user provides the correct password to the authentication server.
6. Access is granted. Without the asynchronous token device and the right PIN, a correct answer to the challenge cannot be generated.

The latest approach to asynchronous tokens no longer requires a physical device but rather software installed on a validated mobile device. Therefore, current MFA solutions tend to follow a flow that is more simplified than the one depicted in Figure 6-2. Because Internet connectivity for mobile devices has become virtually ubiquitous, authentication systems can rely on connected mobile devices to actively participate. Users can install token software on their smartphone, tablet, or laptop and register the device with the authentication server so that, whenever they wish to log on, the authentication server sends a push notification to the token software. Users then respond with a simple tap to approve the logon request, and the token software handles the rest of the interaction, with no further user input required, which means the mobile device with installed and registered software is the authentication token.

Another type of asynchronous token is a Universal Serial Bus (USB) token, which uses public key infrastructure (PKI) technology (e.g., a certificate signed by a trusted certification authority) but does not provide a one-time password. This token is a hardware device that is plugged into a computer's USB port and is encoded with the user's digital signature. Because the presence of the digital signature on the token is enough to

provide proof of possession (something you have), nothing needs to be typed in.

NOTE

One problem with smart cards is that some users leave them unattended in the reader, which means that any user is authorized as long as the smart card remains in the reader.

Yet another type of asynchronous token is a smart card, which is shaped like a credit card and contains one or more microprocessor chips that accept; store; and send information, including that for authentication. To power the embedded microprocessor, most smart cards need a reader, which users insert the card into to begin communication.

One of the significant advantages of a smart card is that the user authentication process is completed between the smart card and the reader at the user location, which means that IDs and authentication data are not transmitted to a remote server, thereby avoiding the "trusted path" problem (i.e., the fact that, when IDs and authentication information are transmitted to a remote server, sensitive information can be exposed to sniffers or tappers). With a smart card, the reader maintains a handshake with the authentication server, directly vouches for the authentication, and then establishes a trusted path in accord with the **Common Criteria for Information Technology Security Evaluation**, also known simply as the *Common Criteria*. This framework allows users, vendors, and testing laboratories to collaborate and share efforts to formally specify, implement, and evaluate information system products.

Finally, many organizations use several varieties of magnetic stripe cards (also known as *memory cards*) to control access to restricted areas, such as sensitive facilities or parking areas.

NOTE

Not all smart cards must be physically inserted into a reader. A contactless, or proximity, smart card contains an embedded radio frequency (RF) transceiver that works when the card is near the reader.

NOTE

For more information about the Common Criteria, visit *www.commoncriteriaportal.org*.

Authentication by Characteristics/Biometrics

Biometrics involves measuring various unique parts of a person's anatomy or physical activities and can be used for both identification (i.e., physical biometrics, also called recognition) and authentication (i.e., logical biometrics). Even though many people associate biometrics with recognition (it is possible to build a massive database of personal biometrics data and then use that to determine someone's identity), that is not its more common use, which is as a technique to validate (i.e., authenticate) a claimed identity. Instead of scanning a face and asking "Who is this?," a better general use of biometrics is to scan a face and ask "Does this face match the characteristics of the claimed identity?" Following are the two categories into which the common biometric measures can be separated:

- **Static (e.g., physiological) measures**—Physiological biometrics measure what you are, examples of which include reading fingerprint patterns, iris granularity, retina blood vessels, facial geometry, and hand geometry.
- **Dynamic (e.g., behavioral) measures**—Behavioral biometrics measure what you do, examples of which include voice inflections, keyboard strokes, and signature motions. Note that biometrics of this

type are sometimes separated into their own category (i.e., authentication by action).

Concerns Surrounding Biometrics.

There are three primary concerns with biometrics:

- **Accuracy**—Each biometric device has at least two error rates associated with it: the false rejection rate (FRR), which is the rate at which valid subjects are rejected, and the false acceptance rate (FAR), which is the rate at which invalid subjects are accepted. The point at which the two rates are equal is called the crossover error rate (CER), which is the measure of the system's accuracy expressed as a percentage. In practice, biometric devices that protect very sensitive resources, such as top-secret military facilities, are generally configured to accept a high level of false rejections, whereas systems that protect less sensitive resources, such as a public-use entry to a low-security building, may grant access to potentially unauthorized personnel so as not to excessively slow down access.
- **Acceptability**—Certain biometric measurements, such as retinal scans, are more objectionable to some users than other biometric measurements, such as signature dynamics. Therefore, understanding the community of users and their comfort level with biometrics is crucial to acceptability. Reasons for low acceptability can be related to hygiene concerns (i.e., multiple people touching readers) or to perceived privacy violations.
- **Reaction time**—Each biometric device requires time for the system to check an identity and respond; therefore, reaction time must be fast for most checkpoints because anything too slow hinders productivity and access. With the increased reliance on cloud-based or other remote services, network performance often plays into authentication techniques. For example, consider facial recognition at airport security checkpoints. If the system needs 30 seconds to identify each passenger, then passenger checkpoint lines would become far longer than they already are.

Types of Biometrics.

There are many types of biometrics, including the following:

- **Fingerprint**—This biometric records fingerprints, the pattern of ridges and valleys on the tip of a finger, and is considered to be highly accurate for verifying a user.
- **Palm print**—This biometric examines the physical structure of the palm and is also considered to be highly accurate. The system reaction time is five to seven seconds, and people tend to accept this type of scan.
- **Hand geometry**—With this type of biometric, a camera takes a picture of the palm of the hand and, using a 45-degree mirror, the side of the hand. An analysis is then made using the length, width, thickness, and contour of the fingers. Hand geometry measurements are highly accurate. System response time is one to three seconds, and people tend to also accept these scans.
- **Vein analysis**—Because human skin is not completely opaque, analysis can also extend under the skin to the specific arrangement of veins in fingers and hands, which is unique to an individual. However, researchers are examining whether certain vascular and connective tissue diseases may change vein patterns and thus result in false negative results.
- **Retina scan**—This type of biometric analyzes the blood vessel pattern of the rear portion of the eyeball area, known as the *retina*, using a low-level light source and a camera. Even though a retina scan is very accurate for identification and authentication, it is susceptible to changes in a person's physical condition, such as those caused by diabetes, pregnancy, and heart attacks, the emergence of which require users to enroll in the system again. Many people do not like retina scans because they feel the scans are intrusive and unsanitary and because they fear they will have to reveal private medical data. Response time averages between four and seven seconds.
- **Iris scan**—This type of biometric uses a small video recorder to record unique patterns in the colored portion of the eye, known as the *iris*, caused by such things as striations, pits, freckles, rifts, and fibers. These scans are very accurate for identification and authentication and are well accepted. Moreover, iris scanning devices provide the capability

for continuous monitoring to prevent session hijacking. Response time is one to two seconds.

- **Facial recognition**—With facial recognition biometrics, video cameras measure certain features of the face, such as the distance between the eyes, the shape of the chin and jaw, the length and width of the nose, or the shape of cheekbones and eye sockets. Fourteen out of about 80 or so common features that can be measured are selected, which are then used to create a facial database. Facial recognition is accurate for authentication because face angle can be controlled, and, because it is passive and nonintrusive, it can continuously authenticate. Currently, however, it is less accurate for identification of individuals in a moving crowd.

Academic research into biometric algorithms expanded at a rapid pace starting in the mid-2010s, and, because of recent advances in machine learning algorithms (i.e., AI), biometrics matching processes are getting faster and more accurate very quickly. Based on this growing body of research, it has become possible to develop highly accurate biometric techniques that are fast enough for mass deployment.

- **Voice pattern**—With voice pattern biometrics, audio recorders and other sensors capture as many as seven parameters of nasal tones, larynx and throat vibrations, and air pressure from the voice. However, these biometrics are not accurate for authentication because voices can be too easily replicated by computer software and accuracy can be further diminished by background noise. Response time is typically slow because it can take over 10 seconds to find a match. Most users will accept this type of biometric, but, because of the relatively long response time, it is not yet popular for everyday use.
- **Keystroke dynamics**—This biometric involves a user typing a selected phrase onto a reference template, during which the keystroke dynamics measure each keystroke's dwell time (i.e., how long a key is held down) and flight time (i.e., the amount of time between keystrokes). Keystroke dynamics are considered very accurate and lend themselves well to two-factor authentication. Because the technology is easy to use when someone is logging on, it combines the ID processes of something you

should know with something you own. Moreover, keystroke dynamics are well accepted and can provide constant authentication.

- **Signature dynamics**—With this type of biometric, sensors in a pen, stylus, or writing tablet are used to record pen stroke speed, direction, and pressure. These dynamics can be very accurate, and most users accept them.
- **Gait analysis**—This type of metric compares the physical movements of people while walking or running to match their unique actions. Although injury or degeneration over time affects people's gait, the overall way in which they walk is generally unique to them.

Advantages and Disadvantages of Biometrics.

Biometrics offer the following advantages:

- A person must be physically present to authenticate.
- There is nothing to remember.
- Biometrics are difficult to fake.
- Lost IDs or forgotten passwords are not problems.

Biometrics have the following drawbacks:

- Physical characteristics might change.
- Physically disabled users might have difficulty with biometric system accessibility, specifically with performance-based biometrics.
- Not all techniques are equally effective, and it is often difficult to decide which technique is best for a given use.
- Response time may be too slow.
- The required devices can be expensive. Moreover, with methods that require lots of time to authenticate, the organization may have to provide a large number of authentication machines so as not to cause bottlenecks at entry and access.

Privacy Issues.

Biometric technologies do not involve collecting data just *about* a person; they collect information *intrinsic* to a person. Privacy issues include the

unauthorized access to the digitally recorded and stored data collected from every person examined, which could lead to its misuse, such as watching a person's movement and actions or allowing a person to pretend to be someone else and thus creating a risk for identity theft.

Authentication by Location

A user's physical location can also be a strong indicator of authenticity, which can provide additional information to suggest granting or denying access to a resource. For example, suppose a user provides a PIN, along with a debit card number, to a card reader that is located in a fuel pump in Topeka, Kansas, but the IP address of the user providing the PIN is located in Tampa, Florida. The separate locations may raise enough suspicion to deny the necessary access to the funds. Contrarily, a taxi-scheduling application may use the customer's smartphone location to validate that a request for pickup is valid. As with other methods, authentication by location should be used only in MFA.

Authentication by Action

One of the newest authentication methods is based on a user's actions, but confusion exists as to whether this method is really a subset of biometrics. We already covered the details of authentication by action in the biometrics section, but be aware that authentication by action is sometimes categorized separately and is also called *something you do*. This type of authentication stores the patterns or nuances of how a person does something, the most common pattern being how someone types. Because most people type with predictable speed and pauses between different keys, their patterns can be stored and used during authentication.

Single Sign-On

A **single sign-on (SSO)** strategy allows users to sign on to a computer or network once and then be allowed into all computers and systems where they are authorized, thus making it unnecessary to enter multiple user IDs or passwords. SSO reduces human error, which is a major part of system failures. Thus, SSO is highly desirable but also difficult to put in place.

Advantages and Disadvantages of SSO

Advantages of SSO include the following:

- The logon process is efficient because the user must log on only once.
- With only one password to remember, users are generally willing to use stronger passwords.
- It provides continuous, clear reauthentication. The SSO server remains in contact with the workstation and monitors it for activity, which allows time-out thresholds that can be enforced consistently throughout the system near the user entry point. When a workstation or endpoint device is not active for a certain period, it can be disconnected, which protects the system from a user's leaving a workstation open to an unauthenticated person who could pretend to be the original user.
- It provides failed logon attempt thresholds and lockouts, which protects against an intruder's using brute force to obtain an authentic user ID and password combination.
- It provides centralized administration, which ensures consistent application of policy and procedures.

The Kerberos Key Distribution Center Server

The Kerberos key distribution center (KDC) server has two functions:

- **Serves as the authentication server (AS)**—An authentication server confirms a user through a pre-exchanged symmetric key, which is based on the user's password and is stored in the KDC database. After getting a request for service from the user, all further dialogue with the user workstation is encrypted using this shared key. Instead of the user sending a password to the KDC, the authentication occurs at the time the Kerberos software on the user's workstation requests the password to create the shared key to decrypt the ticket from the authentication server. The ticket contains the session key for use in communicating with the desired application server. If the wrong password is supplied, the ticket cannot be decrypted, and the access attempt fails.

- **Serves as the ticket-granting server (TGS)**—The TGS provides a way to get more tickets, which usually expire daily or after a few hours, for the same or other applications after the user has been verified. This process eliminates the need to repeat this step several times during a day.

Disadvantages of SSO include the following:

- A compromised password lets an intruder into all areas open to the password owner. Using dynamic passwords and/or two-factor authentication can reduce this problem.
- Static passwords provide very limited security. Two-factor authentication or at least a one-time (dynamic) password is required for access by the user using SSO.
- Adding SSO to unique computers or legacy systems in the network might be difficult.
- Scripts make things easier to administer, but they also expose data and do not provide two-factor authentication to sensitive systems and data.
- The authentication server can become a single point of failure for system access.

Authentication systems share common service requirements in that they all provide a method for users (subjects) to request access to resources (objects) and then provide a way for the request to be either granted or denied. One way to handle SSO authentication is for users to contact a central server for all requests, and another approach is to share user credentials among several servers, which is called *federation*. With federated authentication systems, users see only the initial sign-on process, after which credential sharing occurs behind the scenes among trusted servers. Another approach related to federation is *transitive trust* authentication. In this model, the initial sign-on credentials are forwarded by an authentication server request only to other trusted servers. This authentication process is only slightly different from federation in that, in a federated system, the group of authentication servers is static, whereas, with

transitive trust environments, the group of trusted servers builds over time and can be different for each user and request, depending on the access request path a user follows. Finally, still another approach closely related to federation is *attestation*. Attestation systems use a trusted authority to confirm the authentication process, which is, in effect, relying on another party's ability to securely authenticate a subject.

SSO Processes

Examples of SSO processes include the Kerberos, SESAME, and LDAP methods. Following is a discussion of each one.

Kerberos.

Kerberos is a computer network authentication protocol that allows nodes communicating over a nonsecure network to prove their identity to one another in a secure manner; it is also a suite of free software published by the Massachusetts Institute of Technology (MIT) that applies the Kerberos protocol. It is designed primarily as a client/server model and provides mutual authentication between the user and the server. Moreover, Kerberos protocol messages are protected against eavesdropping and replay attacks.

The Kerberos process begins with users sending their ID and access request through the Kerberos client software on the workstation to the KDC. At the KDC, the authentication server verifies that the user and the requested service are in the KDC database, and, if they are, it sends a ticket, which is the user's unique time-stamped key for the requested service. If the ticket is not used within the designated time, it will not work. Included in the ticket are the user ID and the session key as well as the ticket for the object encrypted with the object's key shared with the KDC.

NOTE

Smart cards can provide SSO services. The use of a smart card in a continuous authentication system can appear to the user as SSO, and all authentication exchanges are transparent to the user. As long as the smart

card is available to the authentication system, the user does not have to provide any credentials to access resources.

With Kerberos, security depends on careful execution and maintenance. Therefore, life spans for authentication credentials should be as short as possible, using time stamps to reduce the threat of replayed credentials, and the KDC must be physically secured because it—particularly the authentication server—is a potential single point of failure. To reduce the risk, redundant authentication servers can be used. Finally, the KDC should be hardened, meaning it should have a secured operating system and application, and should not allow any non–Kerberos network activity.

SESAME.

The Secure European System for Applications in a Multi-vendor Environment (SESAME) is a research and development project funded by the European Commission and developed to address weaknesses in Kerberos. It supports SSO, but, unlike Kerberos, it improves key management by using both symmetric and asymmetric keys to protect interchanged data, making it essentially an extension of Kerberos. Moreover, it offers public key cryptography and role-based access control abilities.

LDAP.

The Lightweight Directory Access Protocol (LDAP) is an open source (i.e., does not rely on any specific vendor's product) protocol for defining and using distributed directory services. One of the core services LDAP provides is handling access control credentials, which makes it easy for administrators to manage logon and access credentials on computers and devices across a network. Although LDAP does not provide a complete SSO solution, it is a part of many SSO solutions. Because LDAP routinely exchanges sensitive information across networks, it is essential to secure the messages; one of the most common ways to do this is to use LDAP over SSL (LDAPS), which uses SSL/TLS for all message exchanges across the network.

Policies and Procedures for Accountability

At this point, you have learned how users are identified (step 1), authenticated (step 2), and authorized (step 3). Now it's time for the last part of the access control process: accountability. **Accountability** involves tracing an action to a person or process to know who made the changes to the system or data, which is important for conducting audits and investigations as well as tracing errors and mistakes. Accountability answers the question, "Can you hold users responsible for what they do on the system?"

Log Files

Log files, which are a key ingredient to accountability, are records that detail who logged on to the system, when they logged on, and what information or resources they used. In the early days of computing, logs were used on systems that were shared by several users in order to be able to charge them for their time and by companies, such as CompuServe and AOL, to record Internet use when it was charged by the hour. On today's networks, time-based billing has given way to either a fixed fee or a fee based on bandwidth usage, but, now, logging is used for more than just billing; it is also a valuable tool to detect, prevent, or monitor access to a system.

Monitoring and Reviewing

One of the main reasons for tracking user access activities is to detect questionable actions and respond to them, which means that you should use software that monitors activity logs and generates alerts when it finds suspicious activity. Moreover, continuous monitoring is an important part of a secure access control system, but not all suspicious activity is obvious. At times, the only way to detect account policy violations is to review user actions over a period of time, a requirement that should be included in the account policy. Such periodic reviews help to validate that user access definitions are correct as well as helping to find inappropriate activity or excessive permissions. Of course, every policy should outline steps to take

to respond to any violations, but knowing how to respond to violations is just as important as finding them in the first place.

Data Retention, Media Disposal, and Compliance Requirements

Many current laws require that organizations take measures to secure many types of data, one example being the Health Insurance Portability and Accountability Act (HIPAA), which protects the privacy of personal health data and gives patients certain rights to that information. Another example is the Fair and Accurate Credit Transactions Act (FACTA), which requires any entity that keeps consumer data for business purposes to destroy personal data before discarding it. More recently, the California Consumer Protection Act (CCPA) and the European Union's General Data Protection Regulation (GDPR) place requirements on how long to retain data and when disposal is mandatory.

These and similar laws require the protection of private data with proper security controls and outline the prescribed ways to handle, store, and dispose of data. If these rules and regulations are not followed, intruders can, for example, simply dive into dumpsters or break into information systems to get sensitive data.

Procedures

Organizations can apply access controls in various forms, providing different levels of restriction and at different places within the computing system. A combination of access controls provides a system with layered, defense-in-depth (DiD) protection, an approach that makes it harder for attacks to succeed because attackers must compromise multiple security controls to reach a resource. Security personnel should ensure that they never rely on a single control, instead protecting every critical resource with multiple controls.

Security Controls

Any mechanism intended to avoid, stop, or minimize a risk of attack for one or more resources is a security control, of which there are several types based on their purpose. Most organizations need a diverse mix of security

controls to protect their systems from all types of attacks. **TABLE 6-1** lists the most common types of security controls.

TABLE 6-1 Types of security controls.

CONTROL TYPE	DESCRIPTION
Administrative	These are policies approved by management and passed down to staff in the form of rules. They are a first line of defense to inform users of their responsibilities. Examples include policies on password length.
Logical/technical	These are additional policies that are controlled and enforced automatically and are intended to reduce human error. For example, a computer can check passwords to make sure they follow the rules.
Hardware	This includes equipment that checks and validates IDs, such as Media Access Control (MAC) filtering on network devices; smart card use for multifactor authentication; and security tokens, such as radio frequency identification (RFID) tags. In this instance, MAC (not the same as the mandatory access controls discussed later in the chapter) is a hardware address that uniquely identifies each node of a network.
Software	These controls are embedded in the operating system and application software. They include the Microsoft Windows standard New Technology File System (NTFS) permissions, user accounts requiring logon, and rules restricting services or protocol types. These items are often part of the ID and validation phase.
Physical	These are devices that prevent physical access to resources, including such things as security guards, ID badges, fences, and door locks.

Media Disposal Requirements

Because most security strategies tend to focus on securing active resources, many organizations tend to overlook the fact that data still exists on retired media or even in the trash. Therefore, media-disposal requirements are necessary to prevent attackers from getting their hands on files, memory, and other protected data. Another consideration is that many organizations allow media to be used again (but only if the original data was not sensitive), an extreme example being media that contains plans for a nuclear weapon. Such

data would not qualify for reuse. You could violate the law if you do not destroy data before discarding the media.

NOTE

Methods of destruction include shredding, burning, or grinding of DVDs, hard drives, USB drives, paper documents, flash memory, and other forms of media.

Another method of disposing of data on magnetic devices (e.g., only traditional hard disk drives or magnetic tapes and not solid-state drives and optical media) is to use a degausser, which is a device that creates a magnetic field that erases data from magnetic storage media. Once data goes through a degausser, not enough magnetic material is left to rebuild it, which prevents its being recovered.

Another method used to destroy data without harming the media that stores it is to repeatedly write random characters over it, a practice called *overwriting*. Overwriting works well if the amount of data to be overwritten is fairly small and the overwriting is fairly fast, whereas large amounts of data or slow writing devices can make this type of data destruction too slow to be useful in a production environment.

Formal Models of Access Control

Most users have encountered access control restrictions (some of the most visible being those protecting access to computer resources), such as when they have typed an incorrect password and been denied access. Because many ways are available for restricting access to resources, it is helpful to refer to models to help design effective access controls. Following are some of the formal models of access control:

- **Discretionary access control (DAC)**—With DAC, the owner of the resource decides who gets in and changes permissions as needed; permissions can be transferred.
- **Mandatory access control (MAC)**—With MAC, permission to access a system or any resource is determined by the sensitivity of the resource and the security level of the subject. Because permissions cannot be transferred, MAC is stronger than DAC.
- **Nondiscretionary access control**—Nondiscretionary access controls are closely monitored by the security, not the system, administrator.
- **Rule-based access control**—A list of rules, maintained by the data owner, determines which users have access to objects.

Other models are based on the work of Biba, Clark–Wilson, and Bell–LaPadula; these models describe the use of access controls and permissions to protect confidentiality or integrity.

Discretionary Access Control

The Common Criteria defines **discretionary access control (DAC)** as follows:

> [A] means of restricting access to objects based on the identity of subjects and/or groups to which they belong. The controls are discretionary in the sense that a subject with certain access permission

> is capable of passing that permission (perhaps indirectly) on to any other subject.

The Common Criteria also notes the following:

> [S]ecurity policies defined for systems used to process classified or other sensitive information must include provisions for the enforcement of discretionary access control rules. That is, they must include a consistent set of rules for controlling and limiting access based on identified individuals who have been determined to have a need to know for the information.

These definitions apply equally to both public and private sector organizations processing sensitive information.

Operating Systems–Based DAC

Operating systems are primarily responsible for controlling access to system resources, such as files, memory, and applications, through access controls, whose maintenance is one of the main jobs of security administrators. Access controls are effective when they ensure that only authorized users can access resources and efficient when they ensure that users can access all the resources they need, but creating access controls that are both effective and efficient can be challenging. Organizations must decide how they will design and maintain access controls to best meet their needs. Following are a few points organizations must consider in developing access control policies:

- **Access control method**—Today's operating systems contain access control settings for individual users (rule based) or for groups of users (role based). Which method an organization uses depends on its size and the specific access rights needed for individuals or roles.
- **New user registration**—Creating new user accounts can be time consuming but must be done quickly so new people can do their jobs. Thus, this process must be standardized, efficient, and accurate.
- **Periodic review**—Over time, users often get special permission to complete a particular project or perform a special task; therefore, it is

important that these permissions be reviewed periodically to ensure they stop when they are no longer needed. Reviewing these permissions periodically solves problems of compliance and auditing by making sure people can access only required areas.

Defining Least Privilege, Separation of Duties, and Need to Know

Least privilege means granting the minimum access that allows a user to accomplish assigned tasks. Stated another way, it means to grant just enough authorization for users to do their jobs, but nothing else. Least privilege is difficult to maintain, but it does protect data from excessive authorization.

Separation of duties is the process of dividing a task into a series of unique activities performed by different people, each of whom is allowed to execute only one part of the overall task. This principle prevents people from both creating and approving their own work and can be a valuable tool to prevent fraud or errors by requiring the cooperation of another person to complete a task. An example of separation of duties is dual control, which includes, for example, a safe with two combination locks, for which each combination is held by two different people, or a missile-control system that requires the simultaneous turning of keys in consoles too far apart for one person to manage.

Need to know is the concept of preventing people from gaining access to information they do not need to carry out their duties, which is a principle that can reduce the chance of improper handling of data or the improper release of information.

All three of these access control principles can be defeated by the following:

- **Collusion**. Users work together (i.e., collude) to avoid the controls, aggregate their authority, and assist each other in performing unauthorized tasks. Job rotation reduces the risk of collusion.

- **Covert channels**. These are hidden (i.e., covert) ways of passing information against organizational policy, of which there are two main types: timing (i.e., signaling from one system to another) and storage (i.e., the storing of data in an unprotected or inappropriate place).

Application-Based DAC

Application-based DAC denies access based on context or content through the application by presenting only options that are authorized for the current user. For example, an automatic teller machine (ATM) menu limits access by displaying only the options that are available to a specific user. You can apply security controls using these types of DACs based on user context or resource contents:

- In a context-based system, access is based on user privileges as defined in the user's own data records. This type of access is usually granted to persons acting in a certain job role or function.
- In a content-dependent system, access is based on the value or sensitivity of data items in a table. This type of access system checks the content of the data being accessed and allows, for example, a manager of Department A to see employee records for personnel that contain an A in the department field but not records containing any other value in that field.

FYI

The Trusted Computer System Evaluation Criteria (TCSEC) provides definitions of both DAC and MAC. These definitions fit the needs of public and private sector organizations that need to protect sensitive information. TCSEC was a prominent standard in the U.S. Department of Defense's Rainbow Series, a collection of computer-security standards and guidelines published in the 1980s and 1990s. Each book in the series had a different-colored cover, which led to the nickname for each book.

The TCSEC had an orange cover and, therefore, was often simply called *The Orange Book*. TCSEC was superseded in 2005 by the Common Criteria.

Permission Levels

Permission levels indicate a subject's rights to a system, application, network, or other resources. In a DAC environment, the authorization system uses these permission levels to determine what objects subjects can access. Following are the various types of permission levels:

- **User based**—The permissions granted to a user are often specific to that user. In this case, the rules are set according to a user ID or other unique identifier.
- **Job-based, group-based, or role-based access control (RBAC)**—Permissions are based on a common set of permissions for all people in the same or similar job roles.
- **Project based**—When a group of people (e.g., a project team) are working on a project, they are often granted access to documents and data related to just that project.
- **Task based**—Based on the concepts of separation of duties and need to know, task-based access control limits a person to executing certain functions and often enforces mutual exclusivity. In other words, if people execute one part of a task, they might not be allowed to execute another related part of the task.

Mandatory Access Control

Mandatory access control (MAC) is another method of restricting access to resources. You determine the level of restriction by how sensitive the resource is, which is represented by a sensitivity label, or classification. Individuals must then be formally authorized (i.e., obtain clearance) to access sensitive information. Security policies defined for systems that are used to process classified information (or any other sensitive information) must include provisions for enforcing MAC rules; that is, they must include a set of rules that controls who can access what information.

NOTE

Remember, sensitivity labels, or classifications, are applied to all objects (i.e., resources), whereas privilege- or clearance-level labels are assigned to all subjects (i.e., users or programs).

Under MAC, the owner and the system jointly make the decision to allow access. The owner provides the need-to-know element because not all users with a privilege or clearance level for sensitive material need access to all sensitive information. The system then compares the subject and object labels that go with the terms of the Bell–LaPadula confidentiality model, which is covered later in the chapter. Based on that comparison, the system either grants or denies access.

Another element of MAC is temporal isolation, or more commonly described as time-of-day restriction, which restricts access of objects to specific times. First, the sensitivity level of objects is classified, and then access is allowed to those objects only at certain times. Temporal isolation is often used in combination with role-based access control.

Nondiscretionary Access Control

In nondiscretionary access control, access rules are closely managed by the security administrator and not by the system owner or ordinary users for their own files. Nondiscretionary access control can be used on many operating systems and is more secure than discretionary access control because the system does not rely only on users' compliance with organizational policies. For example, even if users obey well-defined file protection policies, a Trojan horse program could change the protection to allow uncontrolled access, which is a kind of exposure that is not possible under nondiscretionary access control.

Security administrators have enough control in nondiscretionary access control to make sure that, to preserve confidentiality, sensitive files are write-protected for integrity and readable only by authorized users. Thus,

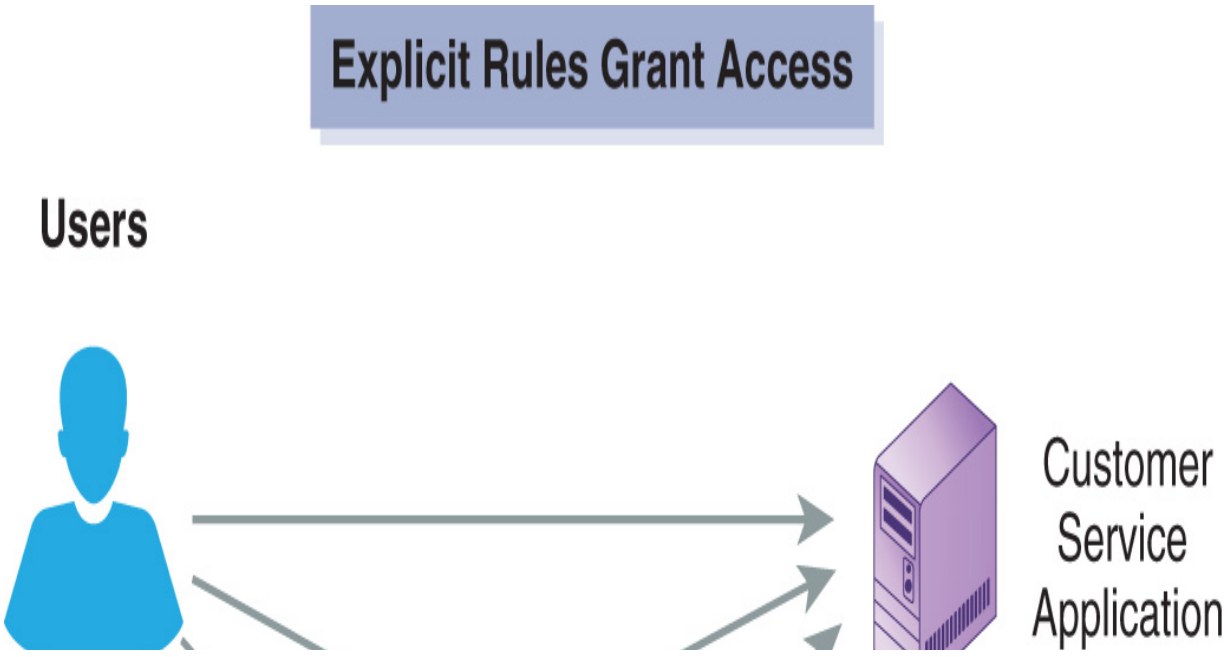
because users can run only those programs they are expressly allowed to run, the chances are reduced that a corrupted program will be used.

Nondiscretionary access control helps ensure that system security is enforced and tamperproof; therefore, if an organization needs to manage highly sensitive information, it should seriously consider using nondiscretionary access control, which does a better job of protecting confidentiality and integrity than DAC. The data owner, who is often the user, does not make access decisions, which allows some of the benefits of MAC without the added administrative overhead.

Rule-Based Access Control

In a rule-based system, access is based on a list of rules that determine who should be granted access. Data owners make or allow the rules; they specify the privileges granted to users, such as read, write, and execute.

The success of rule-based access control depends on how much the data owners are trusted because this type of access control pushes much of the administration to them. For technical and security-conscious users, this type of access control tends to work well, but, in environments with many users or where users lack the necessary technical skills and training, it does not work as well. **FIGURE 6-3** shows how individual rules control each user's permissions.



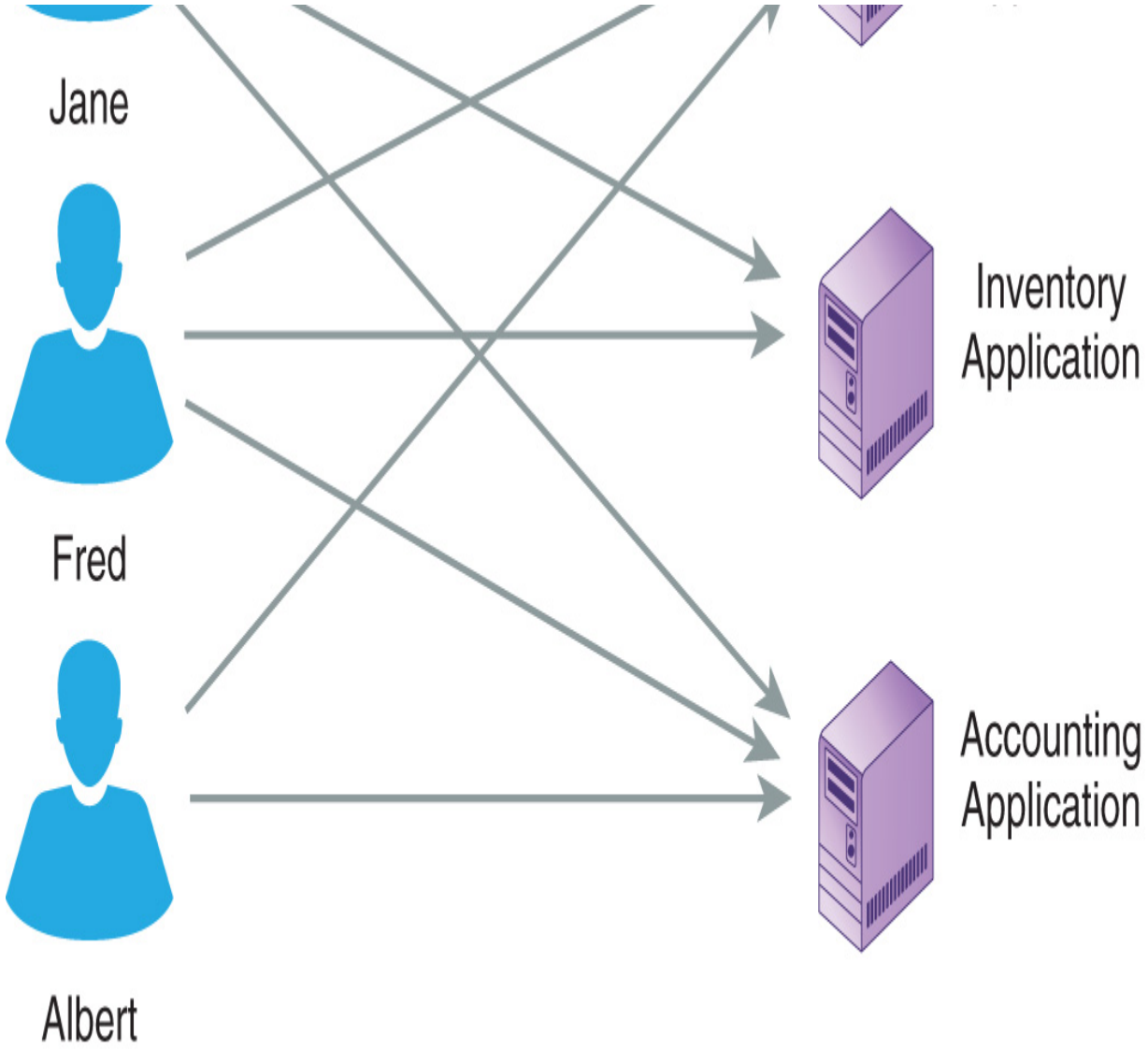


FIGURE 6-3 Rule-based access control.

Access Control Lists

Most operating systems provide several options for associating lists, called **access control lists (ACLs)**, with objects, with different ACL-enabling options provided on the various types of operating systems. For example, Linux and macOS have read, write, and execute permissions, which can be applied to file owners, groups, or global users, whereas Windows has share and security permissions, both of which enable ACLs to define access rules. Share permissions are used to get to resources by a network share, whereas

security permissions are used to get to resources when the user is logged on locally. Some Windows permissions include the following:

- **Share permissions**—Full, change, read, and deny
- **Security permissions**—Full, modify, list folder contents, read-execute, read, write, special, and deny

In both share and security permissions, deny overrides every other permission, but what happens if no ACL exists for a resource? In that case, most authorization systems will use *implicit deny*, which means that, if no rule to grant access exists, access is automatically denied. This approach is more restrictive than implicitly granting access and then adding restrictions, but is more secure.

Because of the greater number of choices when using ACLs as opposed to file permissions, Windows ACLs are said to be more fine grained because they allow a greater level of control. **FIGURE 6-4** shows an ACL.

Hal	
User Hal Directory	Full Control
User Kevin Directory	Write
User Kara Directory	No Access
Printer 001	Execute
Kevin	
User Hal Directory	Write
User Kevin Directory	Full Control
User Kara Directory	No Access
Printer 001	No Access
Kara	
User Hal Directory	Write
User Kevin Directory	Full Control
User Kara Directory	No Access
Printer 001	Execute
Printer 002	Execute

FIGURE 6-4 An access control list.

Role-Based Access Control

Another type of access control is **role-based access control (RBAC)**, which bases access control approvals on the jobs the user is assigned. The security administrator assigns each user to one or more roles, or some operating systems use groups instead. The resource owner decides which roles have access to which resources. Microsoft Windows uses global groups to manage RBAC. **FIGURE 6-5** shows RBAC.

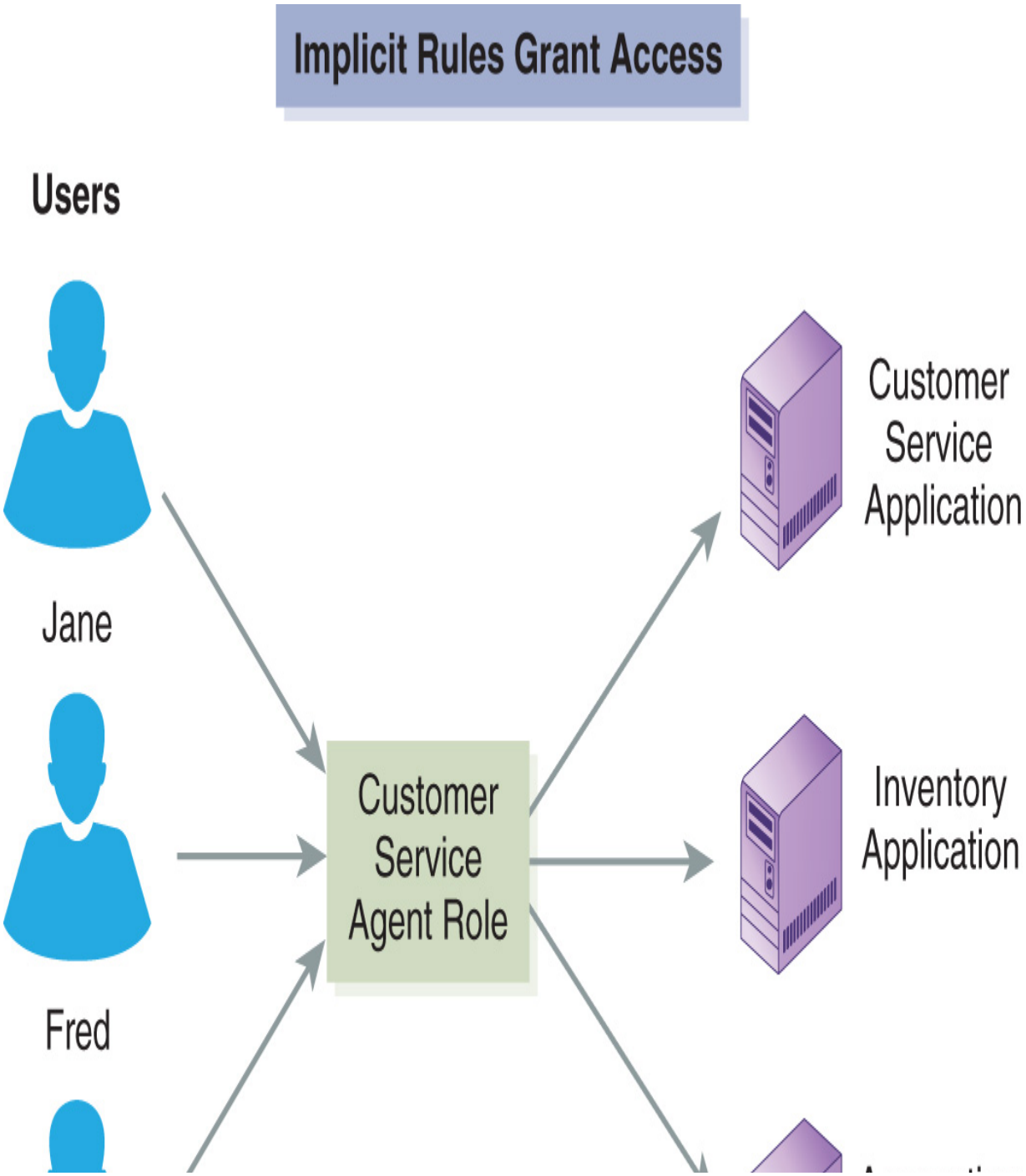


FIGURE 6-5 Role-based access control.

Starting with a clear list of role definitions that fit an organization is key to RBAC; therefore, before you can assign access rules to a role, you must define and describe the roles in an organization. The process of defining roles, approvals, role hierarchies, and constraints is called *role engineering*. The real benefit of RBAC over other access control methods is its ability to represent the structure of the organization and force compliance with control policies throughout it.

Suppose that Jane and Fred in Figure 6-5 should have access to the Inventory application, but Albert should not. As shown in the figure, however, Albert *does* have access to this application, which is a need-to-know violation. This error is caused by the overgeneralizing of roles, a situation that can result in providing more access to individuals than was intended. When assigning roles, consider creating one role for every user or one role for a very small number of users. The "deny permission" option in Windows makes it possible to create a rule that overrides a role, the application of which would fix Albert's excessive permission. But the decision to use the deny permission option is dependent on risk. Users might be given a role with similar privileges to one another and granted access above their need to know in order to reduce administrative costs.

Content-Dependent Access Control

Content-dependent access control is based on what is contained in the data, which requires the access control mechanism (i.e., the arbiter program, which is part of the application, not the operating system) to look at the data to decide who should get to see it. The result is better granularity than the

other access control methods provide, whereby access is controlled to the record level in a file rather than simply to the file level. The cost of this access control granularity is higher, however, because it requires the arbiter program, which uses information in the object being accessed, for example, what is in a record. The decision usually comes to a simple if-then question, for example, "If high-security flag equals yes, then check security level of user." Managers might have access to the payroll database to review data about specific employees, but they might not have access to the data about employees of other managers.

FIGURE 6-6 shows how content-dependent access control can protect data.

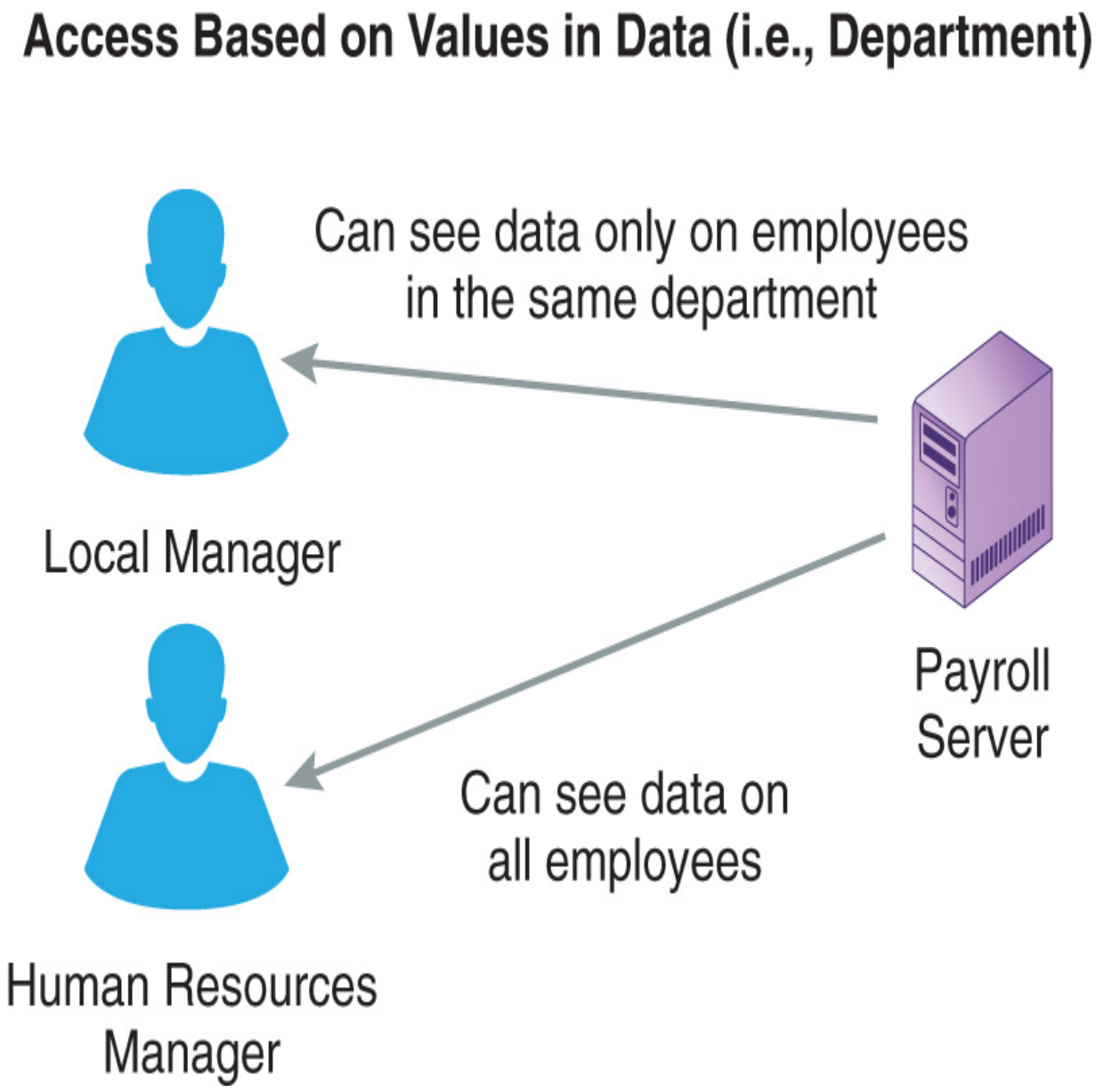

Access Based on Values in Data (i.e., Department)
Can see data only on employees in the same department
Local Manager
Payroll Server
Can see data on all employees
Human Resources Manager

FIGURE 6-6 Content-dependent access control.

Constrained User Interface

With a **constrained user interface**, a user's ability to get into—or interface with—certain system resources is controlled by the user's rights and permissions and the constraints put on the device or program providing the interface. A device such as an ATM or software such as on a public-access kiosk browser lets users reach only specific functions, files, or other resources. The device or software limits their access by restricting their

ability to request access to unauthorized resources, for example, by graying out icons. Following are several methods of constraining users:

- **Menus**—One way to keep users out of certain data is to simply not give them any idea that the data exists. When the user logs on, the menu that comes up does not include closed areas.
- **Database views**—Also called view-based access control (VBAC), this approach is often used with relational databases, in which the database system creates a view for individual users that limits the data they are able to see. Although there may be more data in the database, the user can access only the data defined in the view. Many current databases provide a way to partition a database into several slices, which is a feature called multitenancy; it allows different groups of users to access a database without being able to access each other's data. This ability is important to organizations that want to use the cloud for their shared applications and databases.
- **Physically constrained user interfaces**—The user interface mechanism presents the user with a limited number of options. For example, an ATM offers only a certain number of buttons to push, which makes it a physically constrained user interface.
- **Encryption**—This approach constrains users because it requires them to have the decryption key to reach or read information stored on the system. Encryption also hides information, such as credit card details, from the user.

Other Access Control Models

Other access control models, such as the Bell–LaPadula model, the Biba integrity model, the Clark–Wilson integrity model, and the Brewer–Nash model, have helped shape today's access controls. You will learn about each model in the following sections.

Bell–LaPadula Model

The Bell–LaPadula model focuses on the confidentiality of data and the control of access to classified information. This model is different from the Biba integrity model (covered in the next section), which describes rules to

protect data integrity. In the Bell–LaPadula model, the parts of a system are divided into subjects and objects, and the current condition of a system is described as its *state*. The model guarantees that each state transition preserves security by moving from secure state to secure state, which is a process that ensures the system meets the model's security objectives. The transition from one state to another state is defined by what are known as transition functions.

Biba Integrity Model

In 1977, Kenneth J. Biba defined the first model to address integrity in computer systems based on integrity levels. The model fixed a weakness in the Bell–LaPadula model, which addresses only the confidentiality of data. The Biba integrity model consists of three parts:

- The first part says a subject cannot read objects that have a lower level of integrity than the subject does. A subject at a given integrity level can read only objects at the same integrity level or higher, which is known as a simple integrity axiom.
- The second part says a subject cannot change objects that have a higher level.
- The third part says a subject may not ask for service from subjects that have a higher integrity level. A subject at a given integrity level can call up only a subject at the same integrity level or lower.

Clark–Wilson Integrity Model

Published in 1987 by David Clark and David Wilson, the Clark–Wilson integrity model focuses on what happens when users who are allowed into a system try to do things they are not permitted to do; it also looks at internal integrity threats, which are two components missing from Biba's model. This model looks at whether the software does what it is designed to do, which is a major integrity issue. The Clark–Wilson integrity model addresses three integrity goals:

- It stops unauthorized users from making changes (Biba addressed only this integrity goal).
- It stops authorized users from making improper changes.

- It maintains internal and external consistency.

The Clark–Wilson integrity model defines well-formed transactions and constraints on data to maintain internal consistency, which makes sure the system operates as expected every time. For example, a commercial system should allow a new luxury car sale to be entered only at a price of $40,000, not at $4,000 or $400,000.

NOTE

Unlike the earlier models, which were designed for military uses, this model was designed to be used by businesses.

In the Clark–Wilson integrity model, a subject's access is controlled by the permission to execute the program (a well-formed transaction). Therefore, unauthorized users cannot execute the program (first integrity rule). Authorized users can access different programs that allow each one to make specific, unique changes (separation of duties). Following are two important parts of this model:

- The three access entities—subject, program, and object—combine to form the access triple.
- Integrity is enforced by binding. Subject-to-program and program-to-object binding, which creates separation of duties, enforces integrity and makes sure that only authorized transactions can be performed.

Brewer–Nash Integrity Model

The Brewer–Nash integrity model is based on a mathematical theory published in 1989 to ensure fair competition and is used to apply dynamically changing access permissions. It can separate competitors' data within the same integrated database to make sure users do not make fraudulent changes to objects that belong to a competing organization as well as stop users or clients from using data when they have a conflict of interest.

A **Chinese wall** security policy defines a wall, or barrier, and develops a set of rules to ensure that no subject gets to objects on the other side of the wall. **FIGURE 6-7** shows a Chinese wall in action by illustrating the way an audit company handles audits for competing businesses. In this example, an auditor allowed to work on data related to the Bank of Gloucester is prohibited from getting to any data belonging to the Bank of Norwich. Even though the auditor works for a company that performs the audits for both banks, internal controls at the audit company prevent access between areas that would create a conflict of interest.

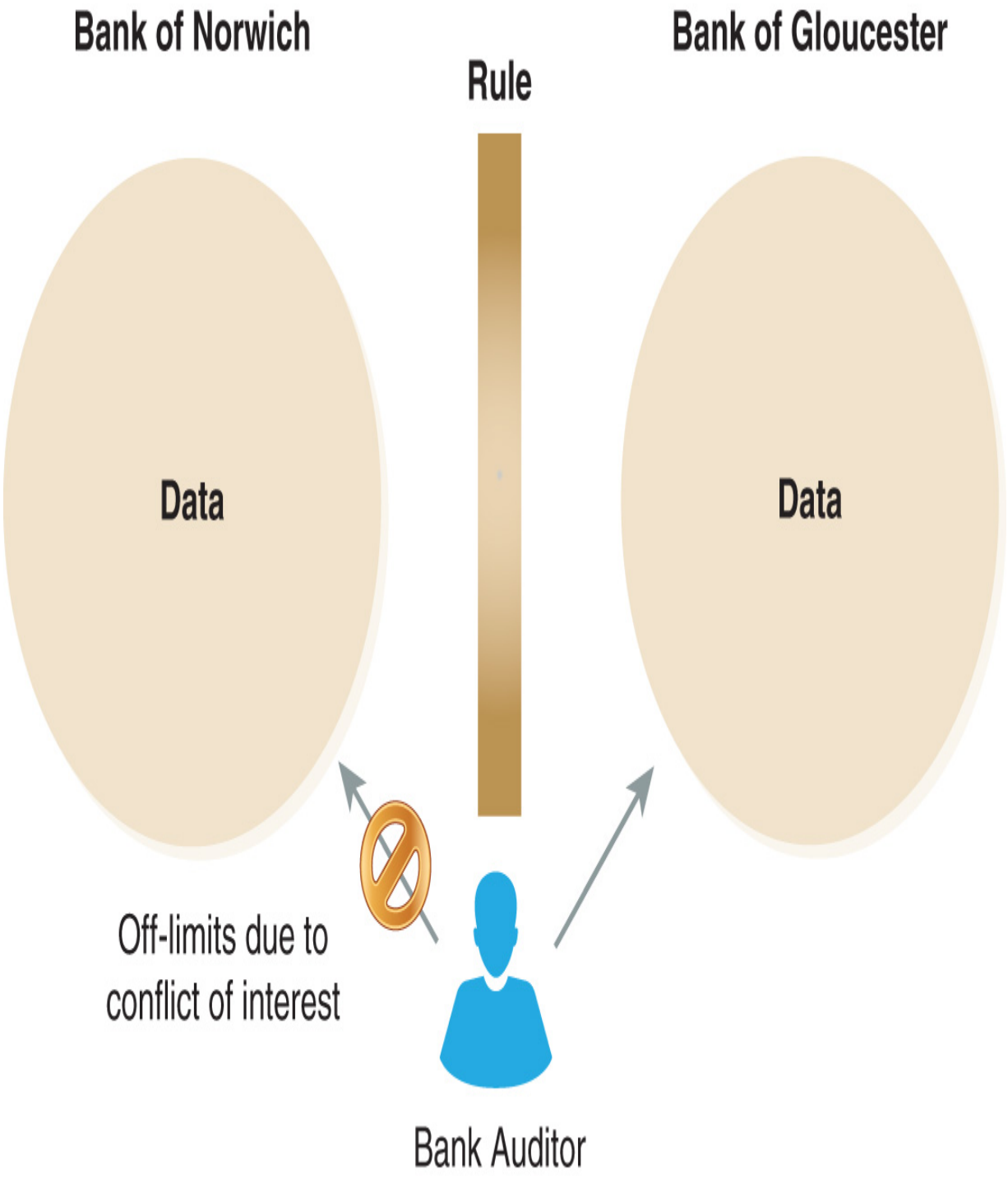


FIGURE 6-7 The Brewer–Nash integrity model.

NOTE

Controls cannot prevent conflicts of interest. Conflicts of interest have to do with individuals' positions, not with the data itself.

This model makes sure conflicts of interest are recognized and that people are prevented from taking advantage of data to which they should not have access. For example, if a user is allowed into one company's data, the data belonging to that company's competitors can automatically be deemed off limits.

Effects of Breaches in Access Control

The failure to control access can give an advantage to an organization's opposition, which might be a military force, a business interested in competitive intelligence, or even a neighbor. The following list details some of the losses that can occur:

- Disclosure of private information
- Corruption of data
- Loss of business intelligence
- Danger to facilities, staff, and systems
- Damage to equipment
- Failure of systems and business processes

Not all incidents have the same effect, which makes some incidents easier to spot than others. For example, losses due to disclosure of business secrets, including business intelligence, often go unnoticed for quite some time. Moreover, by the time corruption of data is discovered, a database and all its backups might be rendered useless, which can easily cause failures in systems and business processes.

Some types of DoS attacks are short lived and can be found quickly and stopped before they cause serious damage. Other types of DoS attacks can inflict more severe damage on an organization because they take longer to evolve and can affect the ability of a business to serve its customers, which may cause some of them to then take their business elsewhere.

Threats to Access Controls

Threats to access controls come in many forms, and a list of them can never be complete because new threats evolve all the time. An example is the peer-to-peer (P2P) risk in which P2P users share their Documents folder with each other by accident, which can expose sensitive documents to other users.

Access controls can be compromised in several ways, including the following:

- **Gaining physical access**—If an intruder has physical access to a device, logical access control is basically worthless because having the device makes it possible for data to be copied or outright stolen, hardware or software keystroke loggers installed, or equipment damaged. For example, the person with the stolen device could start a DoS attack. Furthermore, small removable media, such as writable DVDs, USB memory sticks, or hard drives, create a physical access risk because it's easy to copy data to one of these devices.
- **Eavesdropping by observation**—Security staff may miss the most obvious breach, which is allowing information to be seen, such as data on papers on an authorized user's desk or screen. Another common eavesdropping risk is from smartphones and mobile devices, which include cameras and capability for audio and video recording. Enforcing the policies and procedures to limit first-hand or remote eavesdropping can prevent this kind of data loss.
- **Bypassing security**—Any means of accessing data can lead to a security breach, but developers might think about access via only one method, such as through a website, whereby attackers might easily bypass the security measures in place. Therefore, the information security team must consider other access paths, such as attackers mapping a drive or logging on at the server's keyboard.
- **Exploiting hardware and software**—Attackers often try to install programs, called *Trojan horses*, on a system they control, and the network administrator or workstation owner may not even know the attacker is there.

- **Reusing or discarding media**—Attackers can recover erased or altered information from discarded or reused media. Therefore, it is safer and cheaper to shred documents and physically destroy media than to simply throw them out.
- **Electronic eavesdropping**—Attackers can eavesdrop by wiretapping network cables. However, some media are more resistant to eavesdropping than others, such as fiber-optic cable being safer than copper. Regardless, no medium provides complete protection. Moreover, the use of mobile devices and wireless access points has increased the risk of eavesdropping because many people connect their mobile devices to insecure access points, which are easy targets for attackers.
- **Intercepting communication**—Another variation of eavesdropping is the physical interception of data communications, which is called sniffing, whereby attackers capture network traffic as it passes by. Sniffing is often used in a man-in-the-middle attack. In this type of attack, attackers insert themselves between two victims and relay messages between them, making it seem like the two victims are talking directly to each other over a private connection when, in fact, the attacker is in control of the entire conversation.
- **Accessing networks**—Many organizations' networks often include unprotected and active connections in the form of more drops (i.e., female connectors at wall plates) than they currently need, which allows them to add more users in the event of future growth. The risk is that these connections can be accessed by intruders to gain network access. Furthermore, as organizations add wireless access points, the risks to network access increase. Even though making network access easier benefits legitimate users, it often benefits attackers as well, which makes it important that organizations carefully monitor and restrict all network access points.
- **Exploiting applications**—There are many ways to exploit weaknesses in applications, and attackers are always on the lookout to find new ways of doing so. One such weakness in many applications is buffer overflow, which happens when an attacker enters more characters than expected into an input field, which then allows malicious code to spread throughout the application.

Effects of Access Control Violations

You have seen some of the ways attackers can compromise access controls. But what happens if an attacker is successful at compromising access controls, and what might the impact be? An access control violation can have the following harmful effects on an organization:

- Loss of customer confidence
- Loss of business opportunities
- New legislation and regulations imposed on the organization
- Bad publicity
- More oversight
- Financial penalties

For example, Egghead Software voluntarily reported a breach in the summer of 2000 and was sold to Amazon within a year of the disclosure. Its sale was necessary because, after the breach, customers did not trust the company with their credit cards and therefore hesitated to purchase its products. The corporate world took notice. As a result, other companies stopped reporting their violations in fear that a similar situation might happen to them. Eventually, the government stepped in with new laws that force companies to reveal financial data access breaches.

NOTE

You can find a state-by-state summary of disclosure laws at *www.ncsl.org/research/telecommunications-and-information-technology/security-breach-notification-laws.aspx*.

All 50 U.S. states and many national governments have passed mandatory disclosure laws that affect companies that do business in their jurisdiction or with their jurisdiction's residents. The laws are aimed to protect residents from disclosure of their personally identifiable information (PII), which is often the information that bad guys use to steal identities. However, these laws do not always cover other intrusions, such as theft of intellectual property. Even with the new laws in place, data breaches still happen, and some of them make news headlines, such as those at Yahoo, First American Financial Corporation, Verifications.io, Marriott/Starwood Hotels, and Twitter. The problem of access violations affects many organizations.

Credential and Permissions Management

Credential and permissions management systems provide the ability to collect, manage, and use the information associated with access control. The first step in creating this system is to register users and provide them with valid identification and authentication credentials. Then, access permissions must be defined, permissions associated with users, and maintenance scheduled. It is also necessary to manage permissions and access rules, and, in a dynamic system with many users, this task can easily become overwhelming. To help administrators manage access controls, Microsoft offers a feature called Group Policy, in which a Group Policy Object (GPO) is a collection of settings for users or computers that can be applied efficiently to a group of computers. GPO features allow Windows administrators to define settings in one place that can easily be applied to many users or computers.

Centralized and Decentralized Access Control

Centralized access control is an access control approach in which a single common entity, such as an individual, a department, or a device, decides who can get into systems and networks, which means that access controls are managed centrally, rather than locally. Owners decide which users can get to which objects, and the central administration supports the owners' directives. Centralized authentication services are applied and enforced through the use of **authentication, authorization, and accounting (AAA)** servers.

The benefits of using AAA servers include the following:

- Involves less administration time because user accounts are maintained on a single host
- Reduces design errors because different access devices use similar formats
- Reduces security administrator training because administrators have to learn only one system
- Improves and eases compliance auditing because all access requests are handled by a single system
- Reduces help-desk calls because the user interface is consistent

NOTE

Centralized access control is generally simpler to manage than local control, but the drawback is that, if it fails, large numbers of users can be affected and unable to get into the computer system.

Types of AAA Servers

The following sections will provide information on the leading types of AAA servers: RADIUS, the most popular; TACACS+; the DIAMETER protocol; and the SAML standard.

RADIUS

Remote Authentication Dial-In User Service (RADIUS) is the most popular AAA service. It is an authentication server that uses two configuration files:

- A client configuration file that contains the client address and the shared secret for transaction authentication
- A user configuration file that contains the user identification and authentication data as well as the connection and authorization information

RADIUS follows these steps in the authentication process:

1. The network access server (NAS) decrypts the user's User Datagram Protocol (UDP) access request.
2. The NAS authenticates the source.
3. The NAS validates the request against the user file.
4. The NAS responds by allowing or rejecting access or by requesting more information.

TACACS+

Terminal Access Controller Access Control System Plus (TACACS+) is an Internet Engineering Task Force (IETF) standard that uses a single configuration file to:

- Control server operations
- Define users and attribute/value pairs
- Control authentication and authorization procedures

TACACS+ was originally developed by Cisco Systems before being released as an open standard. Cisco had previously extended the original Terminal Access Controller Access Control System (TACACS) protocol to

develop its own proprietary version called Extended TACACS (XTACACS). TACACS+ was the next step in the evolution and is actually an entirely new protocol. An Options section contains operation settings, the shared secret key, and the accounting filename. TACACS+ follows these steps in the authentication process:

1. Using TCP, the client sends a service request with the header in cleartext and an encrypted body containing the user ID, password, and shared key.
2. The reply contains a permit/deny as well as attribute/value pairs for the connection configuration, as required.

DIAMETER

DIAMETER (not an acronym) is a protocol, based on RADIUS, that defines how a AAA server should communicate and operate. Unlike RADIUS, which works only in a highly fluid or mobile workforce, DIAMETER works well with both stable and static workforces. The DIAMETER protocol includes the following:

- **Base protocol**—The base protocol defines the message format, transport, error reporting, and security used by all extensions.
- **Extensions**—The extensions conduct specific types of authentication, authorization, or accounting transactions.

DIAMETER also uses UDP, unlike RADIUS. Computer applications that use UDP send messages, known as *datagrams*, to other hosts on an Internet Protocol (IP) network, without requiring special transmission channels or data paths. As such, UDP's service is somewhat unreliable because datagrams can arrive out of order and can seem to be duplicated or even missing, issues that UDP simply relies on applications to fix in order to not waste valuable time and resources fixing them itself. Relying on applications to fix these issues makes UDP faster, which is why it's often used for streaming media and online gaming.

DIAMETER uses UDP in P2P mode rather than client/server mode. In P2P mode, a user provides another user with direct access to his or her hard drive, and in turn, the second user also has access to the first user's hard

drive. Unlike client/server mode, no centralized structure exists. **FIGURE 6-8** shows an example of computers connected in P2P mode.

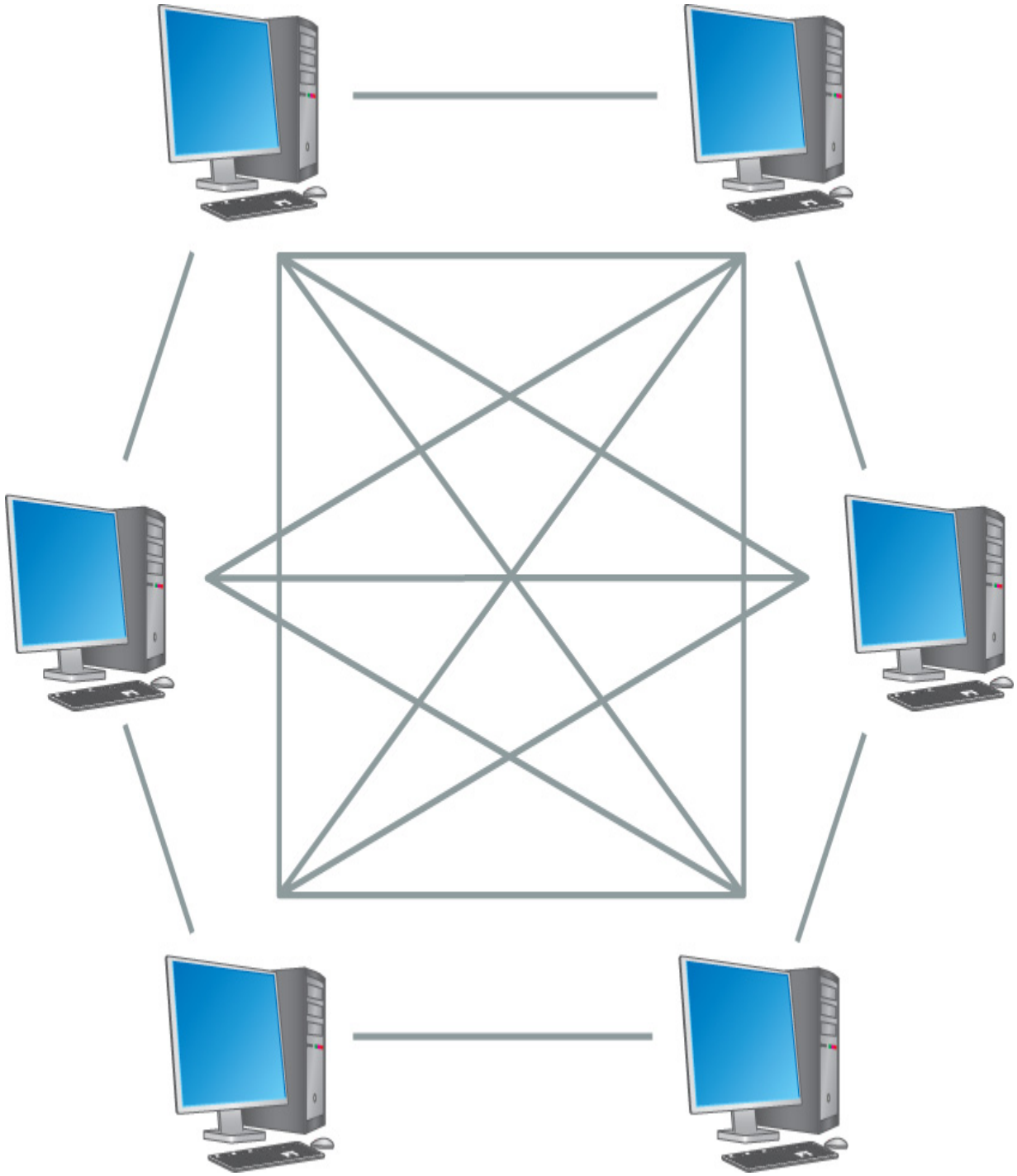


FIGURE 6-8 P2P mode.

As stated, in a client/server mode, the structure is centralized, meaning a client (e.g., a user) connects to a server to request access to certain information. **FIGURE 6-9** shows an example of computers connected in client/server mode.

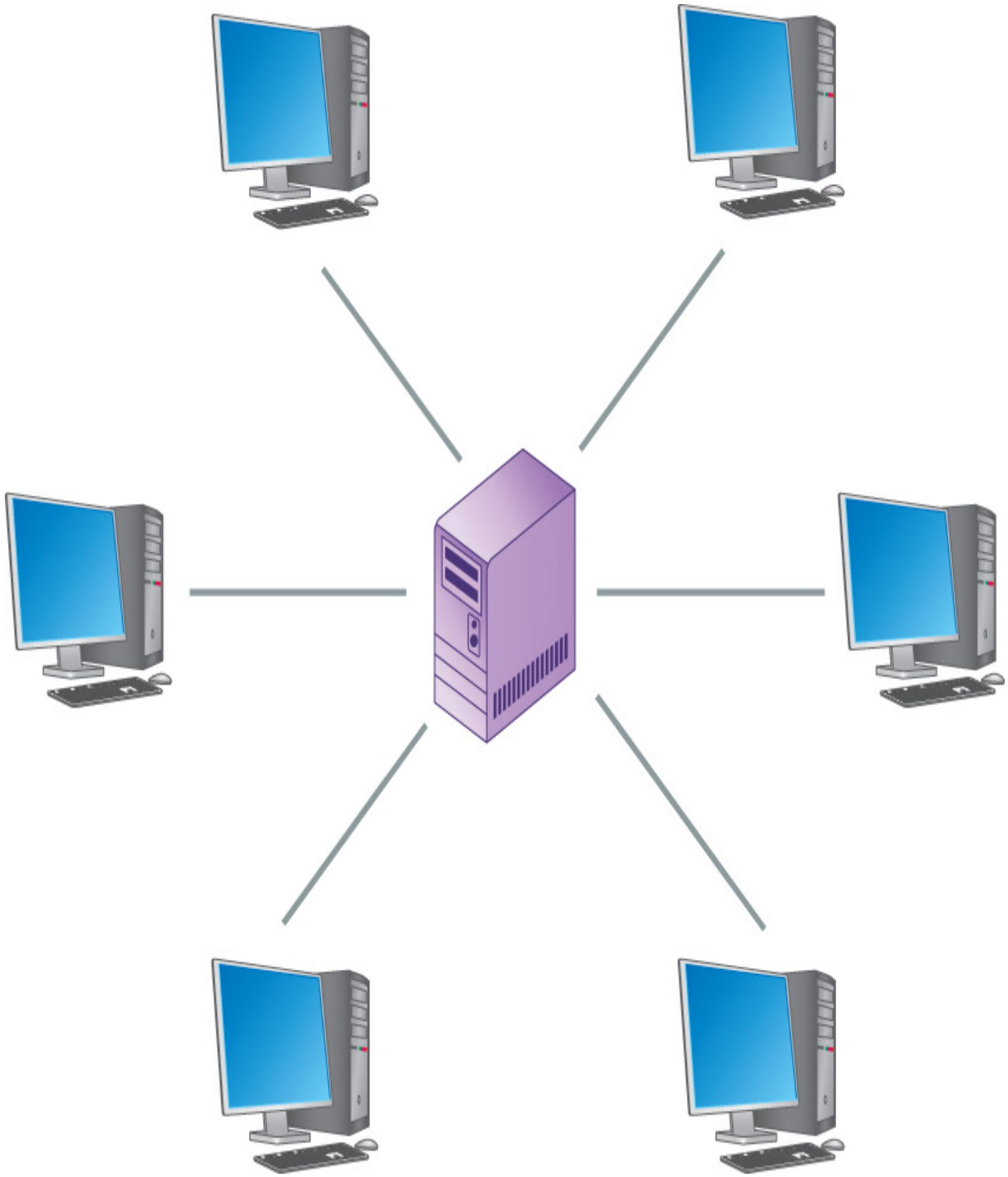


FIGURE 6-9 Client/server mode.

The client/server mode allows servers to initiate requests and handle transmission errors locally, which reduces the time a data packet takes to move across a network connection (i.e., latency) and improves performance. The user sends an authorization request, containing the request command, a session ID, and the user's user ID and password, which is then sent to a network-attached storage (NAS) device to approve the user's credentials. If the credentials are approved, the NAS returns an answer packet, which contains attribute/value pairs for the service requested. The session ID uniquely identifies the connection and resolves the RADIUS problem with duplicate connection identifiers in high-density installations.

SAML

Security Assertion Markup Language (SAML) is an open standard used for exchanging both authentication and authorization data. It is based on Extensible Markup Language (XML) and was designed to support access control needs for distributed systems. SAML is often used in web application access control. However, it is not a complete centralized AAA system but rather a data format specification. We include it in this section because systems that use SAML do depend on a central trusted authority to issue security tokens.

Decentralized Access Control

Another access control approach, called **decentralized access control**, handles access control decisions and administration locally, which means that access control is in the hands of the people, such as department managers, who are closest to the system users.

On one hand, decentralized access control often results in confusion. Why? Because it can lead to loss of standardization and to overlapping rights, both of which might cause gaps in the access control design. On the other hand, a decentralized approach eliminates the single-point-of-failure problem and ends the perception that a central controlling body cannot respond effectively to local conditions.

The two most common examples of decentralized access control protocols are the Password Authentication Protocol (PAP), which uses cleartext usernames and passwords, and the Challenge-Handshake Authentication Protocol (CHAP), which is more secure than PAP because it hashes the password with a one-time challenge number to defeat eavesdropping-based replay attacks. As the explosion in the number of smartphones and tablets continues, so does the need to provide secure access with ever-evolving access controls. Existing protocols are not sufficient to keep up with expanding mobile demands, and new approaches are needed. A relatively new approach, the Initiative for Open Authentication (OATH) is an ongoing effort of more than 30 contributing organizations to develop a reference architecture that supports both centralized and decentralized access control models for strong authentication. From this collaboration, OATH developed several standards to support mobile device authentication, including the HMAC-based one-time password (HOTP) algorithm, which provides a very secure method for authenticating a user using an authentication server. An example of HOTP is the time-based one-time password (TOTP) algorithm, whereby a time stamp is combined with a hashed value to reduce vulnerability to replay attacks.

NOTE

Reference architectures are templates that define the general layout of a process, which are helpful for teams because they provide standard vocabulary, component definitions, and process flows. Teams that need to build solutions can use a reference architecture to help coordinate and focus their work toward a common solution.

The growth of web-based communication and commerce has resulted in applications becoming more distributed and decentralized. As an example, a software application can be run from a web browser that consumes services from many remote servers, which means that what looks like a single application to the user is probably composed of service calls to several

software vendors. But keeping track of identities across multiple domains and vendors is challenging; therefore, as a response to the difficulty of distributed credential management, new types of services, called identity and access management (IAM), have been created to allow verified identities to "travel" with service requests. IAM services enable organizations to outsource the tasks of credential management and simply be able to call the necessary application programming interface (API) functions without having to write everything from scratch. Many organizations, such as IBM and Amazon, provide IAM services for applications that run in their environments. Another service that works with IAM services to manage and secure access to sensitive services and resources, such as backend systems and databases, is called Privileged Access Management (PAM), which is a subset of IAM that controls access of specific accounts with sufficient privilege to access more sensitive resources. IAM and PAM can work together to provide controlled access to an organization's services, resources, and data. You'll likely see these two complementary services implemented together more frequently in the coming years.

Privacy

One of the most visible security concerns is that of **privacy**. The growing awareness of identity theft and the importance of protecting privacy have resulted in new laws and standards to ensure privacy. But personal privacy is only one aspect of this growing issue as organizations become more and more aware of the dangers of privacy violations. Organizations often monitor their staff electronically because they are worried about the following:

- Liability in harassment suits
- Skyrocketing losses from employee theft
- Productivity losses from employees shopping or performing other nonwork-related tasks online

However, electronic monitoring in the workplace creates its own privacy issues because, depending on the country or jurisdiction, the legal levels of staff monitoring might vary widely.

The current thinking is that, for employees to have a reasonable expectation of privacy, they must establish two things:

- They have a subjective expectation of privacy.
- Their subjective expectation of privacy is reasonable.

If either element is missing, no protected interest is established, which means that, if employees are led to expect that something, such as an email message, is private, their employer cannot legally violate that privacy. However, if the company informs employees that email sent over the company's network is monitored, then the employees can no longer claim to have an expectation of privacy. In other words, once the company stakes claim over its cyberdominion, its employees have no right to privacy there.

In view of this situation, companies must clearly communicate their policies for what is acceptable for employees to do and what will be monitored, and, in many cases, employees cannot expect *any* privacy while using corporate systems. An organization's acceptable use policy (AUP) is an important document to set the appropriate expectations for, among other things, privacy.

Logon banners, which are messages that provide notice of legal rights to users of systems and devices, should be used to legally eliminate any expectation of privacy for employees using corporate systems. They are used to gain the following:

- Employee consent to monitoring
- Employee awareness of potential disciplinary action in the event of misuse of the account
- Employee consent to the retrieval of stored files and records

Monitoring in the Workplace

A 2019 American Management Association (AMA) survey titled "The Latest on Workplace Monitoring and Surveillance" found that "73% of organizations use technology tools to automatically monitor email, and 40% of employers assign an individual to manually read and review email." In addition, "66% [monitor] internet connections," while "fully 65% of companies use software to block connections to inappropriate websites."

While email used to be the biggest concern, social media activity has become an even greater concern for leaking private data.

Monitoring in the workplace includes but is not limited to the following:

- Opening mail or email
- Using automated software to check email
- Monitoring keystrokes and time spent at the keyboard
- Checking logs of websites visited
- Getting information from credit-reference agencies
- Collecting information through point-of-sale (PoS) terminals
- Recording activities on closed-circuit television (CCTV)

NOTE

Policies alone do not suffice. Employers must clearly communicate what employees can and cannot do. The best way to do this is through training. When systems or policies change, those changes should be communicated to employees.

Employers monitor their staff to check the quality and quantity of their employees' work, but, in addition, they are often liable for the actions of their employees. Therefore, they need to be sure that their employees are behaving properly. To make sure the staff understands monitoring, an employer should have a clear code of conduct or policy, and employees should know that they could be disciplined if they do not follow the policy.

Cloud Computing

One of the strongest trends in enterprise development is incorporating shared services from external sources and migrating internal data and functionality to hosted computing environments. One such practice is using computing services that are delivered over a network, which is called **cloud computing**. The computing services may be located within the organization's network or

provided by servers that belong to some other network and organization. There are several cloud models available to meet the needs of a diverse user environment, but all cloud services generally fall into one of the following categories:

- **Private cloud**—All the hardware and software required to provide services, including the network infrastructure, is operated for a single organization. The components may be managed by the organization or by a third-party provider, and the actual infrastructure can be located within or outside the organization's network.
- **Community cloud**—This type of infrastructure provides services for several organizations, which all share the cloud environment and use it for their specific needs. The infrastructure can be managed by one of the participating organizations or by a third party.
- **Public cloud**—This type of cloud infrastructure is available to unrelated organizations or individuals and is generally available for public use and managed by a third-party provider.
- **Hybrid cloud**—This type of cloud infrastructure contains components of more than one type of cloud, including private, community, and public clouds. Hybrid clouds are useful for extending the limitations of more restrictive environments and are often used to provide resiliency and load balancing by distributing workload among several infrastructures or segments.

FYI

The Payment Card Industry Data Security Standard (PCI DSS) publishes a document that directly addresses cloud security concerns and is a good resource for cloud computing in general. You can find this document at *www.pcisecuritystandards.org/pdfs/PCI_DSS_v2_Cloud_Guidelines.pdf*.

In the most general case, a **cloud service provider (CSP)** maintains several (sometimes many) data centers with racks of server computers. Each

server runs multiple virtual machines and is able to provide services to many clients simultaneously. CSPs offer different services to their customers over the Internet. Common cloud services include the following:

- **Infrastructure as a Service (IaaS)**—IaaS provides users with access to a physical or virtual machine, to which users load their own operating systems. They then manage all aspects of the machine, just as though it were a local computer.
- **Platform as a Service (PaaS)**—PaaS provides the user with access to a physical or a virtual machine running any of a number of popular operating systems. Unlike IaaS, with PaaS, the CSP manages the operating system and the underlying hardware. Instead of connecting to a local server, the user connects to a virtual server in the cloud, and, once the connection is made, the user treats the cloud instance just like any other computer. The user can install and run software as though the server were in the local data center.
- **Software as a Service (SaaS)**—In the SaaS model, users access software from cloud clients, of which the most basic type is the web browser. Rather than needing to install or manage any software, all users have to do is connect to the correct server and use the software as though it were running in their local network. Examples of popular SaaS include Google Apps™ service, Microsoft Office 365™, and SalesForce®.

There are several advantages to using cloud services over traditional in-house software, and most of the advantages include cost savings. Following are some of those cost-saving advantages:

- **No need to maintain a data center**—The CSP maintains multiple data centers and handles all the logistics and details of making services available anywhere on the Internet.
- **No need to maintain a disaster recovery site**—Since the CSP already maintains services and data at multiple sites, multiple copies of data in the cloud are always available.
- **Outsourced responsibility for performance and connectivity responsibility**—All clients must do is have access to the Internet. The

CSP is responsible for making sure everything works as promised in its contracts.

- **On-demand provisioning**—Cloud customers can increase and decrease the computing power and storage space they purchase based on current needs, a feature that can save organizations substantial amounts of money over maintaining unused hardware. It also means that the organization can respond to increased demand without having to buy and set up new servers.

Cloud computing does have its disadvantages, though. For example, moving services outside the organization makes it more difficult to control the entire environment. Cloud disadvantages include the following:

- **Greater difficulty in keeping private data secure**—Data stored in the cloud is more accessible to both authorized users and attackers. Cloud environments are essentially untrusted. Therefore, data owners must enforce extra precautions to ensure access controls are sufficient to protect their data.
- **Greater danger of private data leakage**—One of the advantages of cloud computing is that the CSP ensures that an organization's data is always available. One way it does this is by keeping multiple current copies of data in different locations. Every additional copy of private data increases the possibility that data may leak to unauthorized users.
- **Greater demand for constant network access**—Access to cloud services depends on the network connection to those services, which means a user who does not have reliable or fast Internet access may encounter difficulties with cloud services. This concern is greatest for mobile users who travel in and out of areas of reliable coverage or who do not have reliable Internet access.
- **Greater need for clients to trust outside vendors**—Releasing private data to a CSP requires some level of trust in that provider. However, trusting a third party with sensitive data may violate some laws, regulations, or vendor requirements. Therefore, before moving data to a cloud, all constraints must carefully be examined due to outside requirements. Although the safest policy is to treat the cloud as an

untrusted environment, there has to be some basic level of trust with a CSP.

One of the most difficult problems organizations encounter today is keeping private data secure in the cloud, the main difficulty being that data moves from a trusted location inside an organization's infrastructure to an untrusted cloud environment. Users can connect from virtually anywhere in the world to cloud resources, which means that the need to identify and authorize users is even more important than with legacy on-premises resources. The basis of access control is nonrepudiation, which means the access controls can associate an identity to a resource request and that association is not disputable. Because users can connect to cloud services from anywhere (including insecure networks and devices), the question is, who should be responsible for identification, authorization, and authentication? To address that question, the Cloud Security Alliance (CSA), a nonprofit organization with a mission to promote best practices for using cloud computing securely, published a guide on cloud security, *Security Guidance for Critical Areas of Focus in Cloud Computing*. The report describes the challenges of cloud computing this way:

> Managing information in the era of cloud computing is a daunting challenge that affects all organizations; even those that are not seemingly actively engaged in cloud-based projects. It begins with managing internal data and cloud migrations and extends to securing information in diffuse, cross-organization applications and services. Information management and data security in the cloud era demand both new strategies and technical architectures. CSA also developed the *Cloud Controls Matrix (CCM)*, which is a framework that defines 133 cloud security control objectives and organizes those objectives into 16 domains. The CCM also maps each control objective to appropriate standards, regulations, and control frameworks.

NOTE

The CSA is a valuable resource for learning about cloud computing security issues, and its website is *https://cloudsecurityalliance.org/*. You can download the most recent version of the *Security Guidance for Critical Areas of Focus in Cloud Computing* report from *https://cloudsecurityalliance.org/group/security-guidance/*.

Cloud computing punctuates the need for good access and identity management. Although many CSPs offer IAM services, applications may need to integrate on-premises and cloud-based identity management across multiple cloud environments. A cloud access security broker (CASB) provides these integrated identity and access management services for cloud-based applications and storage. You can think of a CASB as being an SSO solution that spans multiple clouds. A CASB does move a bit toward centralization, but in the interest of providing users with a rich and secure experience.

There is no easy solution to the problem of managing access control in cloud environments, and researchers are constantly exploring novel ways to ease the burden on organizations. Today, the best approaches are to extend the existing concepts presented in the chapter. Some of the access controls will likely exist in cloud environments. The most important rule is to always use a defense-in-depth strategy and never rely on only a single control to protect any resource.

CHAPTER SUMMARY

In this chapter, you learned that access controls are ways to permit or deny access to protected resources, such as physical assets (e.g., buildings or rooms) or to data and information systems. Furthermore, organizations use them to manage what personnel and processes can and cannot do by specifying who (or what) users are, what they can do, which resources they can get to, and what operations they can carry out. To perform this function, access control systems use several technologies, including passwords, hardware tokens, biometrics, and certificates.

You learned that the four parts of access control are identification, authorization, authentication, and accountability. These four parts create an access control process that can be divided into two phases: the policy-definition phase and the policy-enforcement phase. You learned how you first need to decide who is authorized for access and what systems or resources they are allowed to use. Then, you learned how access is granted or rejected based on the authorizations defined in the first phase. You also learned about the formal models of access control, access control methodologies and challenges, and the effects of access control breaches. And, finally, you learned about cloud computing, its impact on the way organizations and people conduct business, and the heightened importance of access control in cloud environments.

KEY CONCEPTS AND TERMS

Access control
Access control list (ACL)
Access control policy
Accountability
Authentication
Authentication, authorization, and accounting (AAA)
Authorization
Biometrics
Chinese wall
Cloud computing
Cloud service provider (CSP)
Common Criteria for Information Technology Security Evaluation (Common Criteria)
Constrained user interface
Decentralized access control
DIAMETER
Discretionary access control (DAC)
Identification
Logical access control
Mandatory access control (MAC)
Multifactor authentication (MFA)
Physical access control
Privacy
Remote Authentication Dial-In User Service (RADIUS)
Role-based access control (RBAC)
Security kernel
Single sign-on (SSO)
Smart card
Terminal Access Controller Access System Plus (TACACS+)
Token

CHAPTER 6 ASSESSMENT

1. Access controls are policies or procedures used to limit access to certain resources.

   A. True

   B. False

2. Which answer best describes the authorization component of access control?

   A. Authorization is the method a subject uses to request access to a system.

   B. Authorization is the process of creating and maintaining the policies and procedures necessary to ensure proper information is available when an organization is audited.

   C. Authorization is the validation or proof that the subject requesting access is indeed the same subject who has been granted that access.

   D. Authorization is the process of determining who is approved for access and what resources they are approved for.

3. Which answer best describes the identification component of access control?

   A. Identification is the validation or proof that the subject requesting access is indeed the same subject who has been granted that access.

   B. Identification is the process of a subject claiming to be a specific identity.

   C. Identification is the process of determining the people who are approved for access and what resources they are approved for.

   D. Identification is the process of creating and maintaining the policies and procedures necessary to ensure proper information is available when an organization is audited.

4. Which answer best describes the authentication component of access control?

   A. Authentication is the validation or proof that the subject requesting access is indeed the same subject who has been granted that access.

   B. Authentication is the process of creating and maintaining the policies and procedures necessary to ensure proper information is available when an organization is audited.

   C. Authentication is the process of determining the people who are approved for access and what resources they are approved for.

   D. Authentication is the method a subject uses to request access to a system.

5. Which answer best describes the accountability component of access control?

   A. Accountability is the validation or proof that the subject requesting access is indeed the same subject who has been granted that access.

   B. Accountability is the method a subject uses to request access to a system.

   C. Accountability is the process of creating and maintaining the policies and procedures necessary to ensure proper information is available when an organization is audited.

   D. Accountability is the process of determining the people who are approved for access and what resources they are approved for.

6. Physical access controls deter physical access to resources, such as buildings or gated parking lots.

   A. True

   B. False

7. An example of _____ is being presented with some combination of username, password, token, smart card, or biometrics when logging on to a network and then being authorized or denied access by the system.

A. Physical access controls

B. Logical access controls

C. Group membership policy

D. The Biba integrity model

E. None of the above

8. The primary use of biometrics is in recognition of anonymous subjects.

A. True

B. False

9. Which of the following is an example of a formal model of access control?

A. Discretionary access control (DAC)

B. Mandatory access control (MAC)

C. Nondiscretionary access control

D. The Clark–Wilson integrity model

E. All of the above

10. Physical access, security bypass, and eavesdropping are examples of how access controls can be _____.

A. Stolen

B. Compromised

C. Audited

D. Authorized

11. Challenges to access control include which of the following?

A. Laptop loss

B. Exploiting hardware

C. Eavesdropping

D. Exploiting applications

E. All of the above

12. The process of an owner of a resource determining the access and changing permissions as needed is known as _____.

    A. Mandatory access control (MAC)
    B. Discretionary access control (DAC)
    C. Nondiscretionary access control
    D. Content-dependent access control
    E. Role-based access control

13. The security kernel enforces access control of computer systems.

    A. True
    B. False

14. When it comes to privacy, organizations are concerned about which of the following?

    A. Liability in harassment suits
    B. Skyrocketing losses from employee theft
    C. Productivity losses from employees shopping or performing other nonwork-related tasks online
    D. All of the above

Chapter 7
Cryptography

ACCORDING TO *Webster's Revised Unabridged Dictionary*, cryptography is "the act or art of writing in secret characters," and, from the Free Online Dictionary of Computing, cryptography is "encoding data so that it can only be decoded by specific individuals." These two definitions of cryptography delineate its function, but what does cryptography entail? Cryptography comprises the algorithms, or ciphers, used to encrypt and decrypt data, which are collectively called a **cryptosystem**. Most of these cryptographic ciphers take unencrypted data, called **plaintext**, and use one or more **keys** (i.e., a string of numbers or characters known only to the sender and/or recipient) to transform the plaintext into a secret message, which is called **ciphertext**.

The security of a cryptosystem usually depends on the secrecy of the keys, rather than the secrecy of the cipher. Therefore, a strong cryptosystem has a large range of possible keys, making it impossible to try them all in a brute-force attack. A strong system should also produce ciphertext that appears random to all standard statistical tests and resists all known previous methods for performing **cryptanalysis**, or the process of breaking codes.

Essentially, **cryptography** is the art of concealing information from others. It is practiced in business and government as well as in personal transactions, but it is not the only way to make information secure. Instead, it is a set of tools for information technology (IT) security.

Cryptography accomplishes four security goals:

- Confidentiality
- Integrity
- Authentication
- Nonrepudiation

The IT security professional creatively uses these cryptographic tools to meet businesses' security goals.

Chapter 7 Topics

This chapter covers the following topics and concepts:

- What cryptography is
- How cryptography can address business and security requirements
- What cryptographic applications are used in information system security
- What cryptographic principles, concepts, and terminology are
- What cryptographic applications, tools, and resources are
- What the principles of certificates and key management are
- What quantum cryptography and post–quantum cryptography are

Chapter 7 Goals

When you complete this chapter, you will be able to:

- Define the basic concepts of cryptography
- Describe symmetric, asymmetric, and hashing algorithms
- Examine the various uses of cryptography
- Understand the challenges of cryptographic uses
- Define certificate management
- Describe quantum cryptography and post–quantum cryptography

What Is Cryptography?

Cryptography is the art of transforming a readable message into a form that is readable only by authorized users; it is described as follows:

- **Unencrypted information**—Information in understandable form, which is called plaintext, or *cleartext*
- **Encrypted information**—Information in scrambled form, which is called ciphertext

Encryption is the process of scrambling plaintext into ciphertext, and **decryption** is the opposite process (i.e., unscrambling ciphertext into plaintext). For decryption to work properly, the decrypted plaintext must be the same as the original plaintext before encryption.

Traditional encryption and decryption use known mathematical processes, called **algorithms** (i.e., repeatable processes that produce the same result from the same input), for performing their functions, and an algorithm that specifically encrypts or decrypts information is called a **cipher**. The repeatability of the process is important to make sure that information, once encrypted, can be decrypted. **FIGURE 7-1** shows a cryptosystem at work.

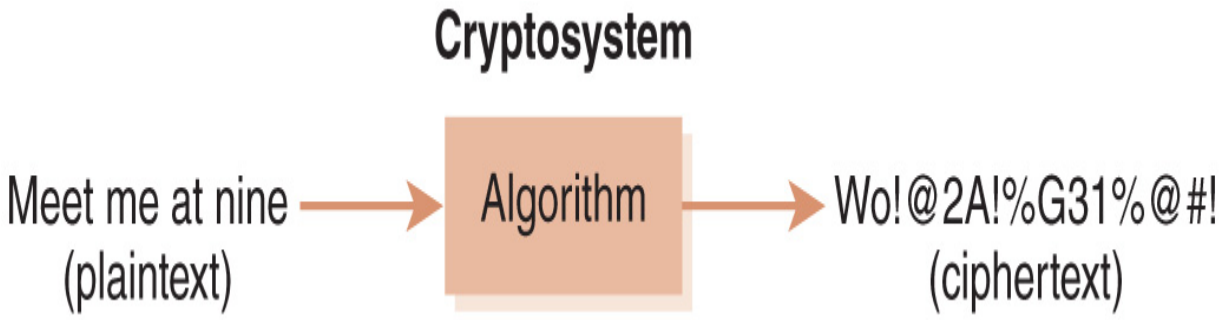


FIGURE 7-1 A cryptosystem at work.

Note that the algorithm you use to encrypt information may or may not be the same one you use to decrypt that information. For example, a simple algorithm that adds *X* to each value to encrypt would have to subtract *X* from each value to decrypt. In addition, some encryption algorithms have no

decryption algorithms, which are one-way algorithms, or hashing functions. The output of a one-way algorithm is a **hash**. Hashing functions are useful for protecting data from unauthorized changes. You will learn about how cryptography is used in various ways later in this chapter.

Technical TIP

Not all cryptographic ciphers require keys. Some newer types of cryptographic algorithms derive their keys from other information, which is an approach that is similar to access controls that use inputs other than passwords. For example, identity-based encryption (IBE) uses the encryptor's identity to derive a key, and attribute-based encryption (ABE) uses descriptive attributes to encrypt and decrypt data.

Most common encryption ciphers require plaintext and at least one cryptographic key as input, which the encryption cipher uses to vary its output so that the intended correspondents can protect their information from anyone else who has the same cipher. By changing the key, you change the output of the cryptographic function, even if the plaintext remains the same.

Encryption ciphers fall into two general categories:

- Those that use the same key to encrypt and decrypt are **private (symmetric) key** ciphers.
- Those that use different keys to encrypt and decrypt are **public (asymmetric) key** ciphers.

Sometimes, the terms *public key* and *private key* refer to the two different keys in asymmetric ciphers, which, together, are a key pair. To avoid confusion, the *symmetric* and *asymmetric* naming convention for ciphers is used here. Note, however, that many sources freely interchange these terms.

TIP

Key-stretching techniques can make a weak key more resistant to brute-force attacks. To do this, a key-stretching function takes a key (generally a weak one) as input and generates an enhanced key that can withstand a more determined attack.

Basic Cryptographic Principles

Given sufficient time and resources, an attacker can eventually decrypt any ciphertext; therefore, the goal of cryptography is not to make ciphertext undecipherable but rather to make the cost or the time required to decrypt it without the key exceed the value of the protected information. Thus, you could effectively protect information that is worth no more than $100 with a cipher that costs $1,000 to break. This is an important concept because it provides one of the basic rationales for selecting cryptographic tools and ciphers.

Without any knowledge of the key, an attacker with access to an encrypted message and the decryption cipher could try every possible key (i.e., **keyspace**, or the number of possible keys to a cipher) to decode the message, which is a brute-force attack. By making the keyspace large enough, the cost of a brute-force attack becomes too high. Assuming that the cipher has no mathematical weaknesses, a larger keyspace usually means more security.

To determine the mathematical weaknesses in ciphers, experts from around the world use open source (i.e., public, as opposed to hidden, closed source, or proprietary) ciphers to subject them to extensive analysis, searching for flaws and weaknesses that could diminish the cipher's strength. Any cipher is far more secure if it withstands public scrutiny without anyone identifying major flaws. The most scrutinized cipher in history is the Data Encryption Standard (DES), published in 1977 as Federal Information Processing Standard (FIPS) 46. Modern computing has searched its keyspace of 72 quadrillion keys without finding a single mathematical weakness.

A Brief History of Cryptography

People have used cryptography to protect information for at least 4,000 years. As soon as people learned to write, they sought to protect their words from prying eyes. Early information security was as simple as hiding it, a method called steganography. For example, legend says that Histiaeus, tyrant of Miletus in the fifth century BC, sent a message tattooed on the scalp of his slave so that any enemy intercepting the messenger would likely not find the information. However, this was not speedy. Miletus had to wait for the messenger's hair to grow back before sending him with the hidden message. In addition, reusability was something of a problem.

WARNING

Always use proven cryptographic algorithms, rather than writing them yourself. History shows that privately developed cryptographic algorithms are weaker than open algorithms. Therefore, there is no substitute for allowing experts around the world to rigorously validate an algorithm's strength.

Steganography is still used today through software, a common way being to embed a message into a large media file, such as a digital image or audio or video file, by altering a single bit for a range of addresses. By altering a single bit in a series of bytes, the steganography software loads the carrier with a secret payload without altering the way the image appears to humans. With most encryption algorithms, it is easy to identify ciphertext because it looks like gibberish, whereas with steganography the method of hiding data makes it very difficult to identify, much less extract. Steganography's inability to be easily detected makes it a growing concern as more and more criminals use it to hide communications from law enforcement authorities.

The science of cryptanalysis, or breaking codes, has been important for many years as evidenced in Queen Elizabeth I having her cousin, Mary Queen of Scots, executed for treason after Sir Francis Willingham had

cracked the secret code that Mary used to communicate with her co-conspirators. Thus, cryptanalysis altered the course of English history.

20th-Century Cryptography

In World Wars I and II, which were the first major wars in which combatants used radios, cryptography played an important role in protecting communications through using codes; however, many opponents' codes were successfully broken, and sometimes more than once. Examples of major decrypted codes were the Japanese Purple cipher and the German Enigma, both of which gave U.S. and British military decision-makers insight into enemy plans. Breaking these codes helped the Allies win decisive military battles, including the Battle of Midway and the Battle of Britain.

The birth of the digital computer made complex ciphers feasible. Digital computers could perform operations in seconds that would normally take hours or days by hand. As a result, modern cryptography moved quickly into the digital realm. The Munitions Control Act of 1950 specifically classified cryptographic ciphers and equipment as Class 13B munitions, which made them tools of warfare and subject to export control and government oversight.

Then, in 1976, Whitman Diffie and Martin Hellman at Stanford University published a paper that revolutionized cryptography through the introduction of the concept of asymmetric key cryptography. Unlike **symmetric key cryptography**, which uses a single key that must be shared among the people who need to receive the message before correspondence can be secured, **asymmetric key cryptography** uses a cipher with two separate keys, one for encryption and one for decryption, and correspondents do not first have to exchange secret information to communicate securely. Moreover, with asymmetric key cryptography, an opponent can intercept everything and still not be able to decipher the message. What Diffie and Hellman had introduced, therefore, was a secure method of exchanging symmetric keys using their asymmetric techniques.

The most common use for this algorithm is to secure communications between two parties, and, to do that, today's network applications commonly establish sessions. One way to securely protect the messages exchanged is to create unique keys, called *session keys*, for each session. Using the Diffie–Hellman algorithm, a sender and a receiver use asymmetric encryption to

securely exchange symmetric keys, after which, each party can then use symmetric encryption to encrypt and decrypt data. Why is this important? Because symmetric encryption algorithms are almost always far faster than asymmetric algorithms and have similar security guarantees.

The Diffie–Hellman algorithm was an enormous step forward in cryptography and is the basis for several common key exchange protocols, including Diffie–Hellman Ephemeral (DHE), which uses modular arithmetic to generate keys, and Elliptic Curve DHE (ECDHE), which uses algebraic curves to generate keys. Both DHE and ECDHE use ephemeral key (i.e., cryptographic keys that are created as new keys for each new session) exchanges, which help make communications sessions more secure. Because each new key exchange uses new asymmetric keys, each communications session setup process is unique. Therefore, if a current session's keys are compromised by an attacker, none of the previous session keys are at risk, a property that is called *perfect forward secrecy*.

Before the digital computer, classic computing addressed the four basic goals of encryption—confidentiality, integrity, authentication, and nonrepudiation—in the following ways. Confidentiality was ensured by encrypting a message, which meant that the sender made sure it was secure as long as an opponent did not have the key and could not find a shortcut to solve it, whereas integrity was often incidental. If decryption produced gibberish, you knew the message had changed in transit. However, if a forger obtained encryption equipment, a fake message could appear legitimate. Authentication—proving the identity of the sender—was possible if both sender and receiver had the same codebook and exchanged elements of it. However, exchanging this information slowly compromised its contents unless you refreshed the codebook. Finally, nonrepudiation—proving that a party did indeed originate a message—was not possible with symmetric key cryptography because anyone with access to the shared key could originate a message. Therefore, before the availability of asymmetric key cryptography, you could not "prove" who wrote a message.

21st-Century Cryptography

Throughout the ages, cryptography has been based on mathematical concepts, and the strength of any cryptographic cipher was based on the difficulty of reversing the operation. Most of today's ciphers depend on the difficulty of

factoring very large numbers, and, even with cutting-edge computers, and lots of them, most ciphers in use would take years to break. However, that could be changing with a new approach to cryptography, **quantum cryptography**, which is based on quantum physics. While a comprehensive coverage of quantum cryptography is far beyond what we can cover here, you should be aware of a few basics. Quantum cryptography uses photons, particles or waves of light, and their unique properties transmitted across an optical fiber channel to create an unbreakable cryptosystem.

Whereas conventional computing uses binary (i.e., a value of 0 or 1) digits, or bits, which can represent only a single value at any time, quantum computing leverages a property of photons to implement qubits, or quantum bits. A qubit can maintain a superposition of both values, 0 and 1, at the same time, which allows quantum computing to implement highly parallel algorithms that could solve problems in a fraction of the time conventional computers can. Existing quantum algorithms, such as the Shor and Grover algorithms, are capable of breaking today's asymmetric and symmetric cryptographic algorithms given a sufficiently large quantum computer, which at this time is not feasible.

The most popular use of quantum cryptography is to exchange encryption keys in a more secure way using current computers and special networking hardware that is not commonly used in today's environments. This key exchange is more secure than the traditional Diffie–Hellman exchange, which is fundamental to today's e-commerce. Even though the quantum approach requires investing in this new hardware, doing so will dramatically increase security.

Following is an explanation of how the quantum cryptography key exchange works. Suppose that Bob, the sender, transmits photons using a polarizing filter in one of four possible orientations: horizontal, vertical, or 45 degrees to the right or left. Alice, the receiver, uses one of two beam splitters—horizontal/vertical or diagonal—to "read" the polarization of each photon, keeps track of which random beam splitter she used to read each photon in order, and then sends that information back to Bob. Bob eliminates the bits that represent the "wrong" beam splitter that Alice used, and thus the remaining bits become the shared secret. In that way, Bob and Alice can agree on a shared secret key they can then use with a traditional symmetric algorithm. The beauty of this approach is that anyone who reads or even

observes photons changes their state. Therefore, if an eavesdropper tries to intercept the photons Bob sends to Alice, those photons will change their state, and the interception will immediately be detected.

WARNING

Do not confuse quantum cryptography with post–quantum cryptography, which refers to techniques that mainly use asymmetric cryptography of sufficient strength to withstand attacks by quantum computers. The goal of post–quantum cryptography is to implement controls today that can withstand the attacks we expect in the coming years.

Cryptography's Role in Information Security

In today's information systems, there are two primary uses of cryptography: to protect data in transit and to protect data at rest. *Data in transit* refers to any data as it is exchanged, most commonly via a network connection, whereas *data at rest* is any data that is stored on storage media and any data in memory. Different cryptographic approaches can help solve the problem of securing data in transit, which is often called communication security, and data at rest.

There are two main approaches to securing communications: encrypting each message before it is sent, which requires software to encrypt and decrypt messages separate from the communications functions, and letting the communication software encrypt and decrypt the messages as they are transmitted or received (often called connection, or transport, encryption because the encryption and decryption occur at the transport layer in the network stack). Common examples of transport encryption protocols include Secure Sockets Layer (SSL) and Transport Layer Security (TLS), which are commonly used to create secure connections between web servers and browsers, and Secure Shell (SSH), which is used to set up secure logon sessions to remote servers.

When it comes to information security, cryptography can satisfy these requirements:

- Confidentiality
- Integrity
- Authentication
- Nonrepudiation

Confidentiality

Confidentiality keeps information secret from unauthorized users. You can lock safes, post armed guards, or whisper in someone's ear in a remote field to ensure confidentiality, but these tactics often are insufficient. Cryptography makes information unintelligible to anyone who does not know the encryption cipher and the proper key. Only authorized users or, eventually, an effective cryptanalysis can get this knowledge. The value of confidentiality is straightforward in that disclosing certain communications that contain confidential information could either harm the correspondents or help an opponent, and, in many cases, a successful attack achieves both goals simultaneously.

Integrity

Integrity ensures that no one, not even the sender, changes information after transmitting it. If the receiver possesses the correct key and uses the right cipher and a message does not decrypt properly, someone or something probably changed the ciphertext in transit.

In addition, cryptography can enforce integrity with hashes or **checksums**, which are one-way calculations of information that yield a result that is usually much smaller than the original message and is difficult to duplicate. For example, a simple checksum of the phone number 1-800-555-1212 could be the sum of each digit, or 30. Even knowing the checksum, you could not re-create the phone number, but you can tell whether the phone number matches the checksum. If one digit is changed, for example, 1-800-555-1212 is changed to 1-900-555-1212, the checksum no longer matches the expected value, and thus you would question the data's integrity. Note, however, that this is not a practical security method because the data could easily be

modified to produce the correct checksum with the wrong phone number. Thus, checksums are more useful in helping to detect accidental and not malicious changes in data. Integrity verification tends to use robust mathematical processes, called hashes, that are hard to reverse engineer. You will learn more about hashes later in this chapter.

Authentication

Authentication confirms the identity of an entity, whether that be the sender, the sender's computer, a device, or information. Humans instinctively authenticate each other based on personal characteristics, such as facial appearance, voice, or skin texture. A traditional military authentication method is a password given to a sentry: If you give the correct password, then the sentry lets you pass. If you do not, you're in trouble. In the digital realm, cryptography provides a way to authenticate entities, the most straightforward of which is a user ID and password. Note that this form of cryptography does not provide strong authentication because anyone else who obtains this fixed information can provide it to the recipient, who will think the user is legitimate.

In general, as a means of authentication, symmetric key cryptography has the same problem as a user ID and password in that an attacker listening in on a conversation where the sender and receiver agree on a cipher and key can then pose as a legitimate user. The symmetric approach to exchanging keys uses the same communications channel as the data and is called an *in-band key exchange*. To be able to authenticate in a symmetric key cryptography world, parties must first securely distribute keys among themselves. For example, they could use asymmetric key cryptography to distribute the symmetric keys and then use the symmetric keys for subsequent correspondence. Another less sophisticated way to exchange keys is to use a different communication channel from the one used for data, which is called an *out-of-band key exchange*. Still another means of exchanging keys would be to have a physical courier deliver the key. This means of exchange is expensive and time consuming for large numbers of users; however, the value of authenticating all parties is great enough in environments such as the military that it is worth the cost.

Asymmetric key cryptography offers a simpler means of authentication. Along with confidentiality, asymmetric key cryptography is the cornerstone

of e-commerce, but cryptography alone cannot solve the authentication problem. One solution is to use a set of authentication and security protocols with cryptography at their core. An example of this solution is Microsoft's NT LAN Manager (NTLM) protocol suite for proving authentication and providing integrity to users. NTLM provides the structure to establish and manage secure communications among distributed network resources. The current version of NTLM, NTLMv2, increases security beyond the original version's limitations.

Nonrepudiation

Nonrepudiation prevents a party from denying a previous statement or action. As an example, suppose an investor sends an email to a broker that states, "Buy 1,000 shares of XYZ at 50." Shortly after the exchange executes the order, XYZ stock drops to 20, upon which the investor denies the buy order and says it was really a sell order. How could you resolve this situation?

Using asymmetric key cryptography, you can prove mathematically—usually to the satisfaction of a judge or jury—that a particular party did indeed originate a specific message at a specific time. The fundamental principle of asymmetric key cryptography is that it uses a key pair to encrypt and decrypt and the originator is the only one who knows one of the keys, which has an irrefutable timestamp. The argument in court would go something like this:

FYI

It's easy to confuse public and private keys. If you were encrypting a message to protect its confidentiality and integrity, you would use the recipient's public key, and only the recipient would be able to decrypt the message using the corresponding private key. Contrarily, if you, as the message sender, want to use encryption to enforce nonrepudiation, you would encrypt the message with your private key. Then, anyone who has access to your public key could decrypt the message, but successful decryption proves that you originated the message.

Encryption does more than just keep messages secret; it can also validate the identity of the sender. Because the encrypted message decrypts with this public key, only the holder of the associated private key could have created this message. The message contains a time-based hash produced by a trusted third-party timestamping device; therefore, neither party could have tampered with it. Thus, we know with effective certainty that this message as decrypted is genuine and originated with this known party, which is nonrepudiation.

Business and Security Requirements for Cryptography

This section will cover information security principles for internal security in businesses, security in business relationships, and security measures that benefit everyone and how cryptography can address them.

Internal Security

A number of security objectives add value to a business. They include the following:

- **Confidentiality**—Confidentiality means that information is readable only by authorized people. For example, most companies keep salary information confidential.
- **Privacy**—Privacy is often confused with confidentiality, but privacy differs from confidentiality in that it protects the release of information that could identify an individual. For example, information that discloses that a person who lives in a certain postal code was treated for a broken arm and a facial laceration on a specific day at a certain hospital may reveal a person's identity. Privacy assures that an attacker cannot assemble available information to identify an individual.
- **Integrity**—Integrity ensures that no one has changed or deleted data. For example, payroll data needs integrity to make sure no one changes a payment after sending it to the check printer.
- **Authorization**—Authorization means approving someone to do a specific task or access certain data. For example, changing salary plans requires proper authorization from management.

NOTE

As privacy issues become increasingly important, an interesting source of tension in security circles becomes more obvious, that between nonrepudiation and privacy. Nonrepudiation means that an action can be positively associated with an individual, whereas privacy means being able to carry out actions without disclosing personal information. But which one is more important? We do not know yet. These two concepts are fundamentally at odds, and the debate continues.

- **Access control**—Access control involves restricting information to the right people. For example, salary plans can be stored in a locked file cabinet to which only human resource employees have the key.

Security in Business Relationships

A number of security objectives add value to relationships between businesses or between businesses and their customers. In addition to those listed previously, these objectives include the following:

- **Message authentication**—Message authentication confirms the identity of the person who started a correspondence. As an example, a broker would like to know that a message to "Buy 1,000 shares of XYZ for account ABC" came from ABC.
- **Signature**—A **digital signature** binds a message or data to a specific entity. Note that this is not a *digitized signature*, which is an image of an electronically reproduced signature.
- **Receipt and confirmation**—Email messages often use receipt and confirmation. Receipt verifies that an entity acknowledges information has arrived, and confirmation acknowledges that the provider has provided a service.
- **Nonrepudiation**—Nonrepudiation means that the person who sends a message cannot later deny it. For example, if the person who made the buy order were to dispute it after XYZ dropped 50 percent, nonrepudiation would prove the original message was valid.

Security Measures That Benefit Everyone

Beyond business and customer relationships, certain security objectives add value to information systems. In addition to those items already listed, these objectives include the following:

- **Anonymity**—Anonymity means a user's identity is disguised. For example, dissidents in a repressive country might want to post information to a web discussion site without the authorities knowing who they are. Unfortunately, criminals and terrorists can use anonymity as well to avoid detection.
- **Timestamping**—Timestamping provides an exact time when a producer creates or sends information. For example, people submitting tax returns at the last minute may want to prove they met the deadline.
- **Revocation**—Revocation stops authorization for access to data. For example, a person who loses a credit card calls the issuer to stop use of the card.
- **Ownership**—Ownership associates a person with information to claim legal rights. For example, most documents have copyright notices that tell who wrote them.
- **High resiliency**—High resiliency describes the ability of a cipher to resist an attack. In many cases, resiliency increases with key length, which increases processing complexity and time. A good cipher provides high resiliency while minimizing processing requirements.
- **Supporting obfuscation**—Supporting obfuscation describes types of ciphers that make it easy to hide the contents of a file without encountering complex key management issues. It is commonly used to protect documents and media files during distribution so that only an authorized recipient should be able to access the unencrypted contents of the obfuscated files.

Although cryptography can be highly useful and provide many benefits in securing data, it does have its limitations. Each algorithm has its own strengths and weaknesses, so choosing the right one for the particular use means basically balancing the benefits and limitations. With a simple cryptographic algorithm, an attacker can learn the algorithm's patterns by

comparing plaintext and ciphertext and thus determine the algorithm's *predictability* in encrypting or decrypting. An algorithm with very low predictability has a high randomness, or *entropy*, value, which is a measure of the randomness of the ciphertext that is the result of a cryptographic operation, whereas high entropy means that ciphertext is more difficult to hack. Of course, even a very secure algorithm becomes more vulnerable when used in the same way with the same key multiple times. Any time a user resubmits the same key multiple times, called key *reuse*, the possibility exists for an attacker to intercept a transmission in a man-in-the-middle attack. Therefore, the most secure keys are ones that are used only once.

NOTE

One of the biggest drawbacks to handling ciphertext is that it is radically different from the plaintext. While you can search text data or carry out calculations with numeric data, you can't do either with ciphertext produced by most cryptographic algorithms. There is a small number of algorithms, called *homomorphic encryption algorithms*, that do support encrypted processing. Partially homomorphic algorithms support either addition, such as the Paillier cryptosystem, or multiplication, such as the ElGamal cryptosystem, on encrypted data. Fully homomorphic algorithms support both addition and multiplication of ciphertext but are too computationally expensive to be viable on today's hardware.

Cryptographic Principles, Concepts, and Terminology

Security objectives are many and varied; therefore, it is important to understand how they work together and how they oppose one another. One of the best summaries of these objectives is found in the *Handbook of Applied Cryptography*. These objectives represent most of the goals of security initiatives, including cryptography. **TABLE 7-1** contains a summary of security objectives. When you try to solve a business security problem, you need to understand these terms. Then you can tell if you could use a cryptographic solution.

TABLE 7-1 Information security objectives.

OBJECTIVE	STEPS TO TAKE
Privacy or confidentiality	Keep information secret from all unauthorized users.
Integrity	Ensure that unauthorized users or unknown processes have not altered information.
Entity authentication or identification	Corroborate the identity of an entity (e.g., a person, a computer terminal, or a credit card).
Message authentication	Corroborate the source of information; authenticate the data's origin.
Signature	Bind information to an entity.
Authorization	Convey an official sanction to do or be something to another entity.
Validation	Provide timely authorization to use or manipulate information or resources.
Access control	Restrict access to resources to privileged entities.
Certification	Endorse information by a trusted entity.
Timestamping	Record the time a user created or accessed information.
Witnessing	Verify the action to create an object or verify an object's existence by an entity other than the creator.
Receipt	Acknowledge that the recipient received information.
Confirmation	Acknowledge that the provider has provided services.
Ownership	Grant an entity the legal right to use or transfer a resource to others.
Anonymity	Conceal the identity of an entity involved in a process.
Nonrepudiation	Prevent an entity from denying previous commitments or actions.
Revocation	Retract certification or authorization.

Cryptographic Functions and Ciphers

A basic understanding of cryptographic ciphers can help in the selection of the right cryptographic products to satisfy an organization's business needs. Each cipher has specific characteristics that may make it desirable or undesirable for any situation. The first issue to consider when evaluating a cipher is its intended use. Are you trying to secure data in transit or data at rest? Once you select a cipher, you still must make additional decisions about such things as key size and operational mode, such as a stream cipher or a block cipher. A *stream cipher* encrypts one byte (or bit) at a time, whereas a *block cipher* encrypts an entire block of data at a time. Deciding on the most appropriate type of cipher is a complex task because there are many subtleties and very few standard answers. As ciphers become more complex, they rely on new techniques to generate keys and transform plaintext into ciphertext.

Two fertile areas of research are elliptic curve cryptography (ECC) and quantum cryptography. ECC ciphers depend on the algebraic structures of elliptic curves over finite fields and can result in very secure ciphertext using smaller keys than more traditional ciphers. However, it imposes a high computational overhead cost. Whereas ECC relies on algebraic structures of elliptic curves over finite fields, quantum cryptography bases its algorithms on the properties of quantum mechanics, a factor that separates basic classic cryptography from quantum cryptography in the difficulty in breaking the cipher. Even though breaking classic ciphers is extremely difficult, breaking quantum cryptography ciphers is theoretically impossible. Of course, quantum cryptography implementations are just as computationally expensive as ECC, require special hardware, and are more difficult to get "right," and, for those reasons, classic cryptography still dominates in today's implementations.

Security Implementations for Businesses

Following is a review of the general classifications of security products and services:

- Authentication (non-PKI [public key infrastructure])
- Access control/authorization

- Assessment and audit
- Security management products
- Perimeter/network security/availability
- Content filtering
- Encryption
- Administration/education
- Outsource services/consultants

By cross-referencing these products and services to the information security objectives mentioned before, you can see which business tools and services satisfy which security objectives and then which of these objectives cryptography can address. **TABLE 7-2** shows how security products and security objectives relate to one another.

TABLE 7-2 Security objectives and security products.

OBJECTIVE	AUTHENTICATION	ACCESS CONTROL	ASSESSMENT AND AUDIT	SECURITY MANAGEMENT	NETWORK SECURITY	CONTENT FILTERING	ENCRYPTION	ADMINISTRATION	CONSULTANTS
Privacy or confidentiality		X			X		X	X	X
Integrity				X	X		X	X	X
Entity authentication or identification	X	X			X		X	X	X
Message authentication	X				X		X		
Signature	X				X		X	X	
Authorization	X	X			X				
Validation		X	X	X				X	
Access control	X	X		X	X	X	X	X	
Certification			X	X			X		X
Timestamping		X			X		X		
Witnessing			X				X		X
Receipt					X			X	
Confirmation					X			X	
Ownership			X				X	X	X
Anonymity							X	X	
Nonrepudiation					X		X	X	X

Revocation	X	X	X

As you can see from the table, you can use cryptography to reach many security objectives. Specifically, cryptography offers the following capabilities:

- **Privacy or confidentiality**—Cryptography scrambles information so that only someone with the right cipher and key can read it. Note that this person could include a clever cryptanalyst.
- **Integrity**—Cryptography protects integrity by providing checksums or hashes. They can be compared with a known table of good values to prove that the data has not changed.
- **Entity authentication or identification**—Someone's ability to encode or decode a message means that person has the cryptographic key or the ability to calculate the key. If a business relationship requires that this key remain secret, possession is proof of valid identity.
- **Message authentication**—Similar to entity authentication, a coded message with a private key proves who the message's writer is. Again, this stipulation should be part of any business contract or formal relationship.
- **Signature**—Cryptography can provide a way to make a digital signature, which can prove that a given person sent a specific message.
- **Access control**—Access control involves encrypting privileged resources and data so that only authorized people can decrypt them and enforce access to them.
- **Certification**—A trusted entity can certify a message and data by adding a cryptographic checksum and a digital signature.
- **Timestamping**—Using asymmetric key cryptography, a trusted device can issue timestamps that attackers cannot forge. Timestamping binds a hash of the timestamped information with the output of a secure, reliable clock.
- **Witnessing**—A third party can add a cryptographic checksum to data to prove that that data exists in a given format at a particular time.

- **Ownership**—Ownership refers to a cryptographic hash created by an owner, added to the data, and then submitted to a trusted third party for corroboration, which is a process for identifying an entity as the data's owner.
- **Anonymity**—Using cryptography, the identity of an entity can be concealed by passing information in an encrypted format that monitors cannot interpret. In addition, using a series of encrypted hops and getting rid of logs can provide an entity with an anonymous presence on the Internet.
- **Nonrepudiation**—Nonrepudiation is an asymmetric key signature of data, agreed to as part of a business relationship, that can prove the sender's identity to the receiver.

Types of Ciphers

Ciphers come in two basic forms:

- **Transposition ciphers**—A **transposition cipher** rearranges characters or bits of data.
- **Substitution ciphers**—A **substitution cipher** replaces bits, characters, or blocks of information with other bits, characters, or blocks.

Transposition Ciphers

A simple transposition cipher writes characters into rows in a matrix and then reads the columns as output. For example, write the message "ATTACK AT DAWN" into a four-column matrix, as shown in **FIGURE 7-2**.

1	2	3	4
A	T	T	A
C	K	A	T
D	A	W	N

FIGURE 7-2 A transposition cipher.

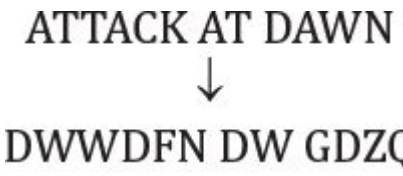
Then, read the information in columns: ACDTKATAWATN, which would be the ciphertext. The key would be {1,2,3,4}, which is the order in which the columns are read. Encrypting with a different key, say, {2,4,3,1}, would result in a different ciphertext, in this case, TKAATNTAWACD.

Note that, in this example, the ciphertext contains the frequency of letters; that is, the most common letters in the English language—E, T, A, O, and N—appear a disproportionate number of times in the transposition ciphertext, which is a clue to the cryptanalyst that this is a transposition cipher.

Transposition ciphers keep all the elements of the original message and simply scramble the information so that it can be reassembled later. Some basic digital transposition ciphers swap bits within bytes to make the data appear unintelligible to the casual reader, an example of which is pig Latin.

Substitution Ciphers

One of the simplest substitution ciphers is the Caesar cipher, in which each letter in the English alphabet is shifted a fixed number of positions, with *Z* wrapping back to *A*. Julius Caesar used this cipher with a shift of three. The following diagram shows an encryption using a Caesar cipher:



Note that there are 25 possible keys for a Caesar cipher because the 26th key maps characters back onto themselves. Note also that this is not a transposition cipher because the letters in the ciphertext were not present in the plaintext.

An example of a Caesar cipher from the 1960s was the Cap'n Crunch© decoder ring, which was included in specially marked boxes of Cap'n Crunch cereal. This ring consisted of two alphabets (*A* to *Z*) written in a circle, with the inner circle immobile and the outer circle rotating. By rotating the outer circle to a set value, you created a one-to-one mapping from one alphabet to the other. Thus, to encrypt, you looked up the desired

character in the inner circle and read off the character on the outer circle, and, to decrypt, you reversed the process.

Another type of substitution cipher is a keyword mixed alphabet cipher, which uses a cipher alphabet that consists of a keyword, minus duplicates, followed by the remaining letters of the alphabet. For example, using the keyword CRYPTOGRAPHY, this type of cipher would yield the following:

```
ABCDEFGHIJKLMNOPQRSTUVWXYZ
↓
CRYPTOGAHBDEFIJKLMNQSUVWXZ
```

Thus, the plaintext word ALPHABET would encrypt to CEKACRTQ.

Any substitution cipher will use these same basic principles, regardless of complexity. To make it harder to break these codes, you can use multiple encryption schemes in succession. For example, you could encrypt every letter with its own substitution scheme, which is known as a Vigenère (*vee-zhen-AIR*) cipher. This cipher works like multiple Caesar ciphers, each with its own shift characters. Say you use the word PARTY, which would use five Caesar ciphers, as the key. Knowing that each character in the alphabet has a value from 1 to 26, you can calculate the encrypted character by adding the value of the plaintext character to the value of the corresponding character in the key. If the sum is greater than 26, just subtract 26 to find the final value. To encrypt the message ATTACK AT DAWN TOMORROW, you would obtain the following:

Plaintext:	ATTACKATDAWNTOMORROW
Key (repeated to match plaintext length):	PARTYPARTYPARTYPARTYPA
Ciphertext (shift characters using the key):	PTKTAZAKWYLNKHKDRIHU

This type of cipher provides more security by making the output appear much more random. Increasing the key length generally increases the security of a substitution cipher.

Instead of transforming each letter a fixed number of positions, you can increase the complexity of a substitution cipher by allowing any letter to uniquely map to any other letter. This type of cipher, called a *simple*

substitution cipher, can be found in many newspapers as a puzzle called a *cryptogram*. In this case, *A* could map to any of 26 letters, *B* could map to any of 25 remaining letters, *C* could map to 24 letters, and so on. Thus, there are 26 factorial, or 403,291,461,126,606,000,000,000,000, possible keys that you can use. Even so, breaking these puzzles is straightforward work, which illustrates an important point: never equate complexity with security.

To make sure a substitution cipher stays secure, you must do three things: (1) ensure that the key is a random sequence without repetition, (2) ensure it is as long as the encrypted information, and (3) use it only once. Such a cipher is known as a one-time pad. The first use of this strategy was in computer systems based on a design by an AT&T employee named Gilbert Vernam. A Vernam cipher creates a bit stream of 0s and 1s, which is combined with the plaintext using the exclusive OR (XOR) function. The XOR operation is true when one and only one of the inputs is true. The XOR function, represented as $\oplus$, has the following properties:

$0 \oplus 0 = 0$
$0 \oplus 1 = 1$
$1 \oplus 0 = 1$
$1 \oplus 1 = 0$

Note that the XOR function is equivalent to the not-equal ($\neq$) function. Using this approach, you can combine a binary stream of data with a binary keystream (i.e., stream of characters from a key) to produce ciphertext, which is how hardware or software uses modern substitution ciphers.

Product and Exponentiation Ciphers

A product cipher is a combination of multiple ciphers, each of which could be a transposition or substitution cipher. An example of a product cipher is the Data Encryption Standard (DES), with a 56-bit key consisting of 16 iterations of substitution and transformation. First published as a Federal Information Processing Standard (FIPS) in 1977, DES is still in use. Because the computers available in 1977 would take more than 90 years to break an encrypted message, its developers thought it was highly secure, but many civil libertarians and conspiracy theorists, as well as professional cryptographers, thought that its designers had built certain weaknesses into it to let the National Security Agency (NSA) open a backdoor in the algorithm

to decrypt messages easily. However, more than 25 years later, no one has found such a weakness. Moreover, advances in cryptography (including differential cryptanalysis, which involves looking for patterns in vast amounts of ciphertext) actually imply that the DES design was even more secure than first suspected. Nonetheless, advances in computing power made the 56-bit keyspace (i.e., 72,057,594,037,927,900 keys) less daunting to search, and, finally, in 1998, the keyspace was searched in less than three days by a special-purpose computer, called Deep Crack, which was built by the Electronic Frontier Foundation. You will read about DES in more detail later in this chapter.

Some ciphers, regardless of type, rely on the difficulty of solving certain mathematical problems, which is the basis for asymmetric key cryptography. These ciphers use a branch of mathematics known as *field theory*. Without getting into too much mathematics, a *field* is any domain of numbers in which every element other than 0 has a multiplicative inverse. For example, all rational numbers form a field; therefore, given $x \neq 0$, you can always compute $1/x$. Fields do not have to be infinite. Instead of counting to infinity, you can restart counting after reaching a particular value. For example, in the United States, people tell time with a 12-hour clock. One hour past 10:00 is 11:00, but one hour past 12:00 is 1:00, not 13:00. Instead of a 12-hour clock, many countries use a 24-hour clock, but the wraparound effect is the same. Things get interesting mathematically when the number of integers in a set is prime because the set of integers from 1 to a prime number represents a finite field.

Another type of cipher, the exponentiation cipher, an example of which is the Rivest–Shamir–Adelman (RSA) encryption scheme, involves computing exponentials over a finite mathematical field and relies on the difficulty of factoring large numbers. It's straightforward to multiply two numbers together but very difficult to factor one large number. You will learn the details of this process later in this chapter.

Symmetric and Asymmetric Key Cryptography

This section will present more information about the differences between symmetric and asymmetric key cryptography and their relative advantages and disadvantages.

Symmetric Key Ciphers

Symmetric key ciphers use the same key to encrypt plaintext into ciphertext and then to decrypt ciphertext back into plaintext, a fact that inherently represents a basic limitation for these cryptosystems. Because these ciphers require that both parties first exchange keys to be able to securely communicate, the parties must first be able to talk securely to exchange keys. This chicken-and-egg problem is what made cryptography difficult in the past for any large, dispersed organization, with the exception of governments, the military, and well-funded people.

As an example of this problem, suppose Alice and Bob work for the ABC Company and they want to exchange pricing information for a proposal to a new client, MNO Plastics. Alice is in the office, and Bob is in the field at the client site and cannot get to the company's internal network; therefore, all information between Alice and Bob must go back and forth across the Internet.

Enter Eve, who works for an overseas competitor of ABC and whose job is to gather as much intelligence as she can about ABC's proposal and bid to MNO Plastics. She has authorization to monitor, disrupt, or masquerade any communications to achieve her mission (for the sake of discussion, the obvious legal issues here can be set aside). Assume that Eve can monitor all communications to and from Bob as they pass through a node Eve controls.

Therefore, the problem in this situation is, how do Alice and Bob create a secure communications session if they have not agreed to anything in advance? Suppose that Alice and Bob agree to use DES to encrypt their information, but, because DES is a publicly available algorithm, Eve can also download a copy of the DES software. Therefore, when Alice sends a message to Bob to use BIGBUCKS as the key and Bob acknowledges this

convention and sends his encrypted message to Alice using this key, Eve, listening in on the communications, can use the same key to decrypt Bob's message so she can send his information to her company.

Even though Alice and Bob can agree to change keys any number of times, each time they do, Eve can learn of this key change and adjust accordingly, and, with symmetric key cryptography, there is no way around this problem. Each party must exchange keys with the other party to know what key the other is using. Even if a key is encrypted with a key-encrypting key (i.e., one that is used only to encrypt other keys), the key-encrypting key must be exchanged at some point, which means that an attacker can intercept the key-encrypting key when it is exchanged.

To overcome this dilemma, a message must travel on a path that Eve cannot monitor, which is known as out-of-band communication, using a secure channel. Suppose in this case that Alice and Bob agree to use DES and Alice tells Bob to call her on his cell phone and tell her what key he wants to use. They agree on a 56-bit key and then begin exchanging information. Even though Eve can read all Internet traffic, she cannot monitor cell phones and therefore is out of the loop. Of course, before Bob left on the business trip, Alice and Bob could have agreed to use a particular key, which is also out-of-band communication because it takes place outside the communications channel used for sending and receiving messages.

Now, ABC Company has a choice to make, either issue the same key to all employees or separate keys to each employee. Issuing the same key to all employees makes correspondence easy because any employee can correspond securely with any other employee around the world, but what happens when a disgruntled employee quits and joins a competitor, taking the key with him? In this case, ABC has to create a new key and reissue the new key to everyone worldwide, which could be a time-consuming and expensive process.

Alternatively, if ABC decides that a single point of failure is unacceptable, it could choose to issue separate keys to each employee. However, because both parties have to use the same key with symmetric key ciphers, each employee–employee pair must have its own unique key. Thus, if ABC had 10 employees, it would need 45 key pairs (9 + 8 + 7 + 6 + 5 + 4 + 3 + 2 + 1); 100 employees, 4,950 key pairs; and 10,000 employees, 49,995,000 key pairs, based on the number of key pairs required for n correspondents being

$(n\ (n-1))/2$. Moreover, each time an employee joined or left the company, a key pair would have to be added or deleted for each of the other employees. Clearly, symmetric key systems do not scale well.

Scalability remained an intractable problem for cryptologists (and governments, militaries, and businesses) until 1976, when Whitfield Diffie and Martin Hellman published their paper, "New Directions in Cryptography," in the *IEEE Transactions on Information Theory* journal, in which they proposed a radical new approach that offered a potential solution.

Asymmetric Key Ciphers

In the introduction to their paper, Diffie and Hellman pointed out that "[t]he cost and delay imposed by this key distribution problem is a major barrier to the transfer of business communications to large teleprocessing networks." As a solution to the common problems encountered with key distribution scalability, they introduced the concept of **public key cryptography**, which is referred to as *asymmetric key cryptography* in the chapter. Public key cryptography is a system that allows correspondents to communicate only over a public channel using publicly known techniques. With this system, they can create a secure connection and do not need to wait until an out-of-band letter arrives with a key in the envelope. Nor do they need to issue and manage millions of key pairs just in case someone wants to communicate securely with a new correspondent. The impact of this discovery is profound and has far-reaching effects on cryptography.

Asymmetric key ciphers have four key properties:

- **Two associated algorithms that are inverses of each other exist**—This solution involves two components associated with each other, which means you use one algorithm to encrypt and another to decrypt.
- **Each of these two algorithms is easy to compute**—You can use this approach in computer software without too much difficulty. As a result, it becomes a practical approach for secure digital communications.
- **It is computationally infeasible to derive the second algorithm from the first algorithm**—You can post one key widely for anyone to use without compromising the contents of its associated key. These key

pairs comprise a public key and its associated private key, called a public–private key pair. Because public key cryptosystems have private keys, it is apparent why the chapter uses the asymmetric key–naming convention.

- **Given some random input, you can generate associated key pairs that are inverses of each other**—Any party can create public–private key pairs and keep one private and post the other in a directory for any correspondent to use. Because the private key is secret and never transmitted, an eavesdropper cannot learn this value.

As an example of how public key cryptography works, suppose that Bob wants to send Alice a message. Alice has already created her private key, which she keeps safe, and her public key, which she puts on her website. Bob uses Alice's public key to encrypt the message, "Hi Alice!" and then sends the encrypted message to her. Because Bob used Alice's public key to encrypt the message, only Alice can decrypt it with her private key. If Alice wanted to respond to Bob's message, she could encrypt her response with Bob's public key and send the message back to him.

One of the closest equivalents in the everyday business world to asymmetric key ciphers is the night deposit box at a bank, whereby a merchant takes his receipts to the bank; opens the slot with his key; and drops the envelope with the money down the chute, where it slides into the safe. If he then turns around and a robber holds him up at gunpoint and demands his key, the merchant can safely surrender it and run away, but, because the envelope has dropped out of reach, the robber will be unable to access it. The next morning, the bank officer can use her key to open the safe, remove the money, and deposit it into the merchant's account. Each party has a different key, but the keys are associated with each other. Make this process reversible, where the bank officer could leave messages for the merchant, and the result is the equivalent of an asymmetric, or public, key cryptosystem.

Cryptanalysis and Public Versus Private Keys

Encryption makes plaintext unreadable to anyone except an authorized person with the right software and key. If the data is valuable, however, cybercriminals may try to break the encryption.

You can break a cipher in two ways:

- Analyzing the ciphertext to find the plaintext or key
- Analyzing the ciphertext and its associated plaintext to find the key

A cipher is unconditionally secure if no amount of ciphertext will give enough information to yield a unique plaintext, but, given enough time and resources, almost any cipher can be broken. However, a cipher's main purpose is not to be impossible to break but rather so difficult to break that it is computationally infeasible. For example, assume that an organization generates new keys every week. Therefore, if an attacker can crack any key in 13 days, the cracked keys would be useless by the time the attacker tried to use it because it would have already been superseded by a new key. Thus, a cipher that an attacker cannot break economically (relative to the value of the protected data) is strong, or computationally, secure.

Technical TIP

The only unbreakable cryptographic cipher is the Vernam, or one-time pad, cipher. You will read more about that later in this chapter. You can also find out more about the Vernam cipher at *www.pro-technix.com/information/crypto/pages/vernam_base.html* .

There are four basic forms of cryptographic attack:

- **Ciphertext-only attack (COA)**—In a ciphertext-only attack, the cryptanalyst has access to only a segment of encrypted data and has no choice as to what that data might be. An example of having only a segment of encrypted data is the cryptogram found in some daily newspapers. Note, however, that by understanding the context of the information, as in the newspaper cryptogram, one can infer that certain words or formatting may be present. **FIGURE 7-3** shows a ciphertext-only attack. The sample of ciphertext is available, but the plaintext associated with it is not.

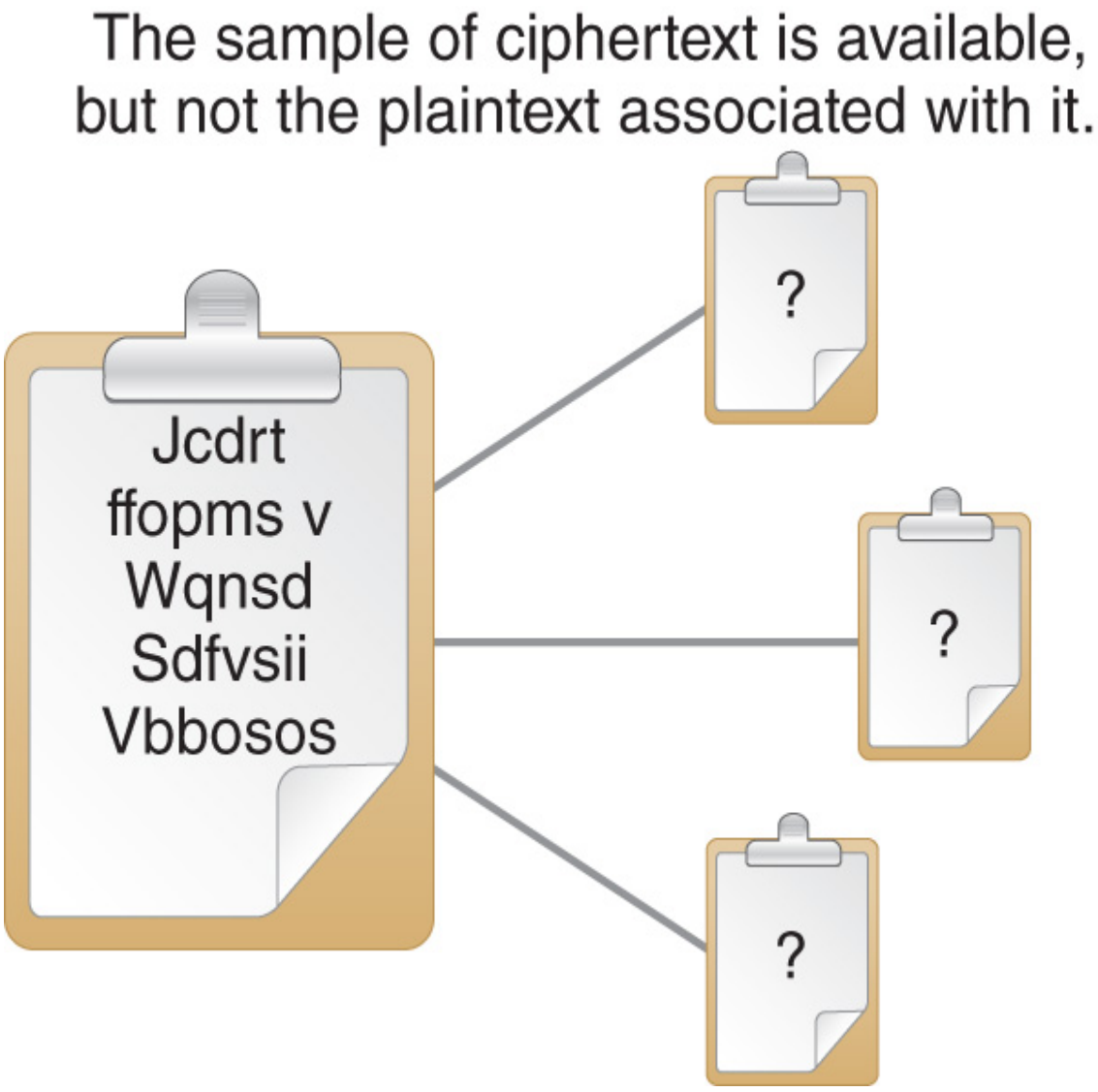


FIGURE 7-3 A ciphertext-only attack (coa).

- **Known-plaintext attack (KPA)**—In a known-plaintext attack, the cryptanalyst possesses certain pieces of information before and after encryption. For example, all secure logon sessions may begin with the characters LOGON, and the next transmission may be PASSWORD. A secure encryption cipher should resist an attack by an analyst who has access to numerous plaintext–ciphertext pairs. **FIGURE 7-4** shows a KPA.

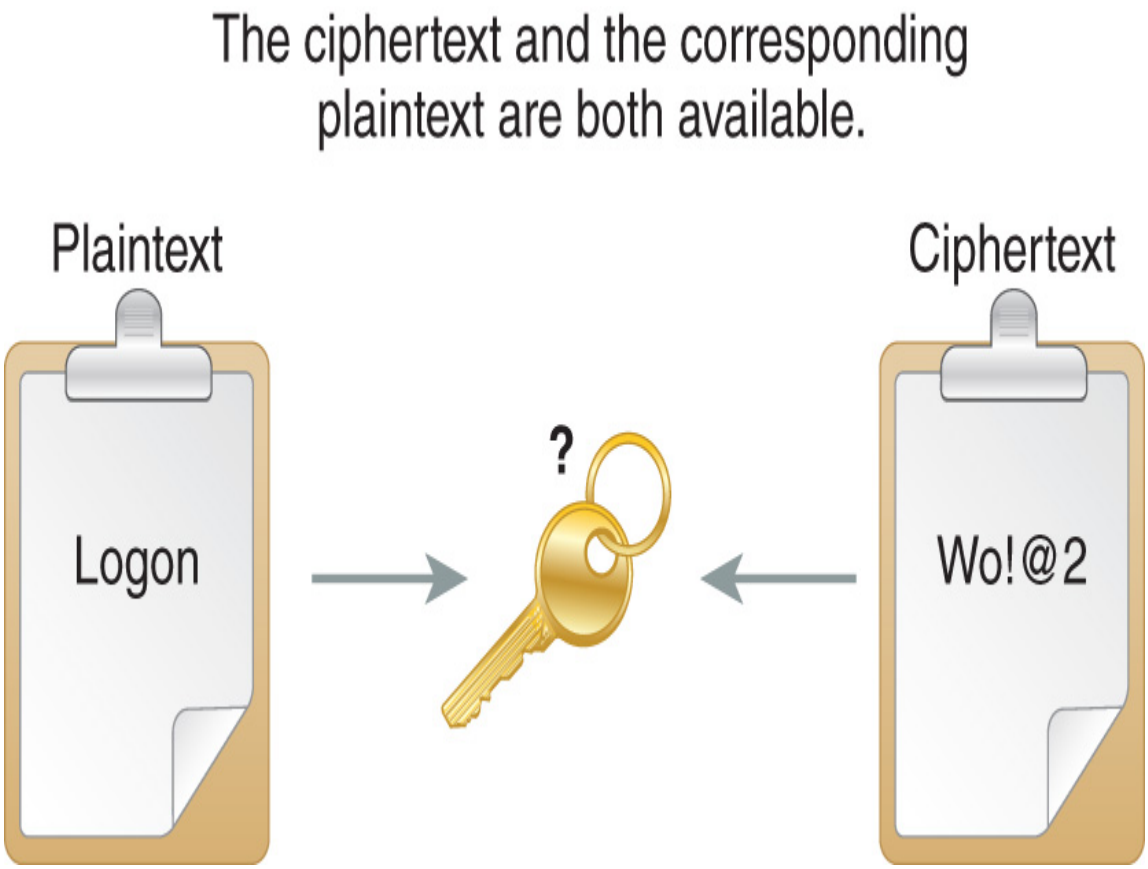


FIGURE 7-4 A known-plaintext attack (kpa).

- **Chosen-plaintext attack**—In a chosen-plaintext attack, the cryptanalyst can encrypt any information and observe the output, which is the best case for the cryptanalyst because it offers the most flexibility (and insight) into the encryption mechanism. An example of software vulnerable to a chosen-plaintext attack is the encryption offered by older versions of Microsoft Office software applications in which only the letter *A*, then *B*, and so on could be encrypted, to try to discern what the cipher is doing.
- **Chosen-ciphertext attack**—A chosen-ciphertext attack is a special case because it is relevant in only asymmetric key systems and hash functions. In a chosen-ciphertext attack, cryptanalysts submit data, which is coded with the same cipher and key as they are trying to break, to the decryption device to see either the plaintext output or the effect the decrypted message has on a system. As a simple example, an owner trains a guard dog to respond only to commands spoken in Navajo so that a burglar, even though he does not know Navajo, can make a series

of noises and sounds that might prompt a response from the dog (even if not the response he seeks). By observing the dog's reaction to various apparently nonsensical commands, the burglar might be able to make the dog lie down and play dead. These types of attacks have particular uses in attacking encrypted email, but the complexity of the mathematics involved is too great to allow a discussion of them here.

Symmetric and Asymmetric Key Cipher Resistance to Attack

Cryptanalysis has several objectives, including the following:

- Derive the plaintext of a target message.
- Determine the key used to encrypt a target message.
- Derive the algorithm used by a particular cipher.
- Solve the general mathematical problem underlying the cryptography.

Cryptographers use many tools in cryptanalysis, with such names as linear cryptanalysis, differential cryptanalysis, brute force, exhaustive search, and information theory. In the most direct case, the analyst must use an encrypted message to derive its associated plaintext. Many ciphers used today are open source, which means that the analyst has access to the logic for the encryption and decryption functions, whereas the security of closed source, or proprietary, ciphers stems in part from the fact that the analyst does not necessarily know how the cipher works.

For example, the United States did not have access to a Japanese Purple cipher device in World War II, which meant that codebreakers had to determine how the machine worked by analyzing faint patterns in the ciphertext. Once they had determined the patterns, they could then change the order of different keys to decrypt message traffic, which then allowed them to identify the keys. Once the keys were identified, anyone could read all traffic coded for that time period with the same keys.

In some cases, analysts found a solution by attacking the underlying mathematics of a cryptosystem. In the late 1970s, some vendors made security products that used asymmetric key cryptography based on a simplified version of the knapsack problem called the *subset sum problem*. Unfortunately for the vendors, Len Adelman developed a general solution to the subset sum problem in 1982 that could run on an Apple II computer, and,

with that solution, an entire class of security products became obsolete overnight.

Today, the basis of most commercial asymmetric key cryptography is the difficulty of factoring large numbers. For example, with pen and paper, it is relatively easy to calculate 757 × 769 = 582,133, yet reversing the operation to derive the two factors that comprise the result of 582,133 is not as easy. The classic approach would involve trying 2, 3, 5, 7, 11, 13, and so on until a prime factor is found, which would take 134 guesses. Although this process becomes much easier with a computer, imagine that the two prime factors comprise 100 digits each. To put this concept into perspective, following is a 100-digit prime number:

6,513,516,734,600,035,718,300,327,211,250,928,237,178,281,758,494,417, 357,560,086,828,416,863,929,270,451,437,126,021,949,850,746,381

Moreover, the preceding number would be only one of two factors.

Keys, Keyspace, and Key Management

This section will discuss how to describe the function of keys, the importance of keyspace size, and the requirements for adequate key management.

Cryptographic Keys and Keyspace

What is a cryptographic key and how does it function? Simply stated, a key is a value that is an input to a cryptosystem and participates in transforming a message in a particular manner. For each key used, a well-designed cryptosystem produces different outputs of the same message. Think of a key this way: a cipher performs a particular task, and a key gives the specific directions for how to do it.

Physical keys are similar to cryptographic keys. Many popular door locks have five tumblers, each with 10 possible positions. Thus, there are 10^5, or 100,000, possible cuts for house keys, which provides a reasonable assurance that a person trying a random key in just any front door will not get in. Regarding this example of physical keys, the set of all possible keys, or 100,000 keys, comprises a keyspace. Usually, although not always, in a cryptosystem, the larger the keyspace, the more secure the algorithm. Following is an illustrative example.

How large is the keyspace for a briefcase with two three-digit locks? Combinations run from 000–000 to 999–999, so there are 1,000,000 keys in the keyspace. Does this mean a thief would have to try 1 million combinations before guessing the correct combination? Not necessarily. That thief could be incredibly lucky and guess the correct combination on the first try. Alternatively, a thief could be incredibly unlucky and try every possible combination before finding the correct combination on the last try. On average, an attacker will guess the correct combination halfway through searching the keyspace. Does this mean that an attacker would need to try, on average, 500,000 combinations? If each attempt took two seconds and the attacker worked nonstop day and night, he or she should need more than 11

days to open the briefcase. However, the actual resistance of a briefcase to brute-force attack is closer to 17 minutes. Why is this so?

It has to do with a weakness in the briefcase algorithm. Because there are two separate locks with 1,000 combinations each, on average it takes 500 attempts to guess each subcombination. After finding the left combination, the attacker proceeds to the right combination. At most, the attacker will need to try 1,000 + 1,000, or 2,000, combinations. On average, however, the attacker will need to try only 1,000. At two seconds each, this would take 16 minutes and 40 seconds.

The preceding example effectively illustrates that increased keyspace, or even an increase in the number of bits in a key, does not necessarily provide much more security. If a briefcase maker wanted to sell you a product with six three-digit locks, claiming that the briefcase had more possible combinations (i.e., keys) than DES, would you want to buy it? Probably not, because knowing what you know now, you can calculate that it would take less than an hour to open this secure briefcase.

Key Management

One of the most difficult and critical parts of a cryptosystem is **key management**. Although the mathematics of a cipher might be difficult for an attacker to solve, weaknesses or errors in key management often offer a means of compromising a system. As covered previously, key management of a symmetric cryptosystem can be difficult and complex, which can lead to shortcuts that can be fatal to the otherwise secure cipher.

World War II history gives an example of how poor key management can wreck a cryptosystem. From 1940 to 1948, to encode messages sent over commercial telegraph lines, the Soviet Union used one-time pads, which are theoretically unbreakable: the key is very close to random, is as long as the information it protects, and does not repeat. Moreover, it is not possible to detect a pattern in the ciphertext. However, the difficulty of distributing and managing long keys in a worldwide wartime environment led to some places running out of cipher keys. Each location knew better than to reuse its own keys, but what harm could there be in using another station's one-time pad? Plenty, as it turns out.

If you use the XOR function to encrypt, then encrypting message A with keystream X becomes:

$$A \oplus X = E(A)$$

where E (A) represents the encrypted message containing A. Remember that the XOR function has the interesting property that anything XOR'd with itself is 0 and anything XOR'd with 0 is itself. To decrypt this message, you recombine it with key X to recover the message:

$$E(A) \oplus X = A \oplus X \oplus X = A$$

The problem with reusing keying material from another station is that the U.S. intelligence agencies were trying to capture all encrypted traffic from all locations, after which they tried to correlate the messages. For example, a message from New York to Moscow in 1943 might have used the same one-time pad as a message from the embassy in Sydney to the embassy in Cairo in 1944. An interesting thing happens when you combine two messages encrypted with the same key:

$$\begin{aligned} A \oplus X = E(A)\ B \oplus X &= E(B) \\ E(A) \oplus E(B) &= A \oplus X \oplus B \oplus X \\ &= A \oplus B \oplus \cancel{X \oplus X} \\ &= A \oplus B \end{aligned}$$

Now, you can use message A to encrypt message B. If you recall from the discussion on transposition ciphers, the ciphertext stores patterns in plaintext. Moreover, using one message to encrypt another keeps much of the statistical properties of the plaintext. It turns out that breaking these messages is rather straightforward. Note that the calculations are solving for the plaintext, not the encryption key. Once the message has been decrypted, you could calculate the key by combining the ciphertext with the plaintext.

The U.S. code name for this counterintelligence operation was Venona, through which the effort to try to break these messages continued from the 1940s all the way until 1980. The U.S. government then declassified the intercepted messages between 1995 and 1997. Entire books have been written about this project, and, just in case there was any doubt that Julius

and Ethel Rosenberg spied for the Soviet Union, the incriminating information can be read in the decrypted messages today.

Key Distribution

Key distribution techniques typically take one of three forms:

- **Paper**—Paper distribution requires no technology to use. However, it does require a person to do something to install the key, and this human role can introduce errors or give a disgruntled person a chance to compromise a system.
- **Digital media**—Digital distribution can be in the form of DVDs, links on websites or social media, or email. Note that you must protect the keys in transit by using some form of secure transmission, such as tamperproof cases and registered mail for physical media, whereas, for electronic distribution, a higher-level key, known as a key-encrypting key, must protect the keys in transit and storage, which, of course, requires that you first distribute the key-encrypting key by some alternate secure mechanism. Key-encrypting keys should be used only to encrypt other keys, not data, and excessive use of any key could lead to its being compromised.
- **Hardware**—You can distribute a key via hardware with a USB flash drive, a smart card, or any other removable storage device. The advantage to this method is that you transfer the keys directly from the key-transport mechanism into the crypto device without anyone viewing them and no copies exist outside of these components.

To protect against key interception in transit, you can split keys. Splitting a key into two equal-sized pieces is not a good idea because, if an attacker intercepts one piece, brute-forcing the other half of the key is much easier (remember the briefcase example). Therefore, one strategy to split a key K is to generate another random key J, which becomes the key-encrypting key, and then combining K and J to produce an encrypted key. You would then send this encrypted key on one channel and the key-encrypting key by another channel. Even if attackers intercept one of the two messages, they do not learn the underlying key.

Channel 1: J
Channel 2: K ⊕ J
Recombine: J ⊕ K ⊕ J = K

Note that this scheme requires a new key-encrypting key for every key.

Key Distribution Centers

Rather than each organization creating the infrastructure to manage its own keys, a number of hosts could agree to trust a common key distribution center (KDC). With a KDC, each entity requires only one secret key pair, that between itself and the KDC. Both Kerberos and ANSI X9.17 use the concept of a KDC.

As an example of how a KDC works, suppose Alice wants to initiate a secure communications session with Bob, so she sends an encrypted message to the KDC, which upon receipt, picks a random session key, encrypts copies in both Alice's key and Bob's key, and returns both keys to Alice. Alice decrypts her session key and uses it to encrypt a message, which she sends, along with the session key encrypted in Bob's key (which Alice cannot read) to Bob. Bob gets both messages, decrypts the session key using his secret key, and uses the session key to decrypt Alice's message.

Digital Signatures and Hash Functions

For many business requirements, you should understand the use of digital signatures and hash functions and what types of ciphers to use.

Hash Functions

To ensure that the values of a message have not changed—either deliberately or through transmission error—a summary of the information, which can be verified through a repeatable process, can be appended. This summary is called a checksum. For example, to make sure a string of digits has not changed in transmission, you could append the sum of all the digits to the end of the message. If the recipient adds up the digits and reaches a different value, then the recipient can assume that there was an error in transmission and the message should be resent.

Credit cards have a hash digit that validates the card number. The algorithm for calculating this digit is the LUHN formula, based on ANSI X4.13. To calculate whether a credit card number is valid, follow these four steps:

1. Starting with the second digit on the right, multiply every other digit by two.
2. If the result of any doubling is greater than 10 (i.e., 8 + 8 = 16), add the digits of this result and then add all the doubled digits.
3. Add all other digits, with the exception of the last digit (the checksum), to this total.
4. The difference between the sum and the next multiple of 10 is the check digit. For example, the correct hash digit for credit card number 5012 3456 7890 123X is 6.

A hash is like a checksum but operates so that a forged message will not result in the same hash as a legitimate message. The output of a hash function is a hash value. Hashes are usually a fixed size and act as a fingerprint for the data. Message creators can publish a hash as a reference so that recipients

can see whether the information has changed. Software publishers often provide hash values so that customers can check the integrity of the software they receive. To be effective, hashes usually have to be long enough so that creating an alternative message that matched the hash value would take far too much time.

Digital Signatures

Digital signatures are not digitized signatures (i.e., electronic images of handwritten signatures) but rather function to bind the identity of an entity to a particular message or piece of information. They do not provide privacy or secrecy but instead ensure the integrity of a message and verify who wrote it. Digital signatures require asymmetric key cryptography. **FIGURE 7-5** shows a digital signature.

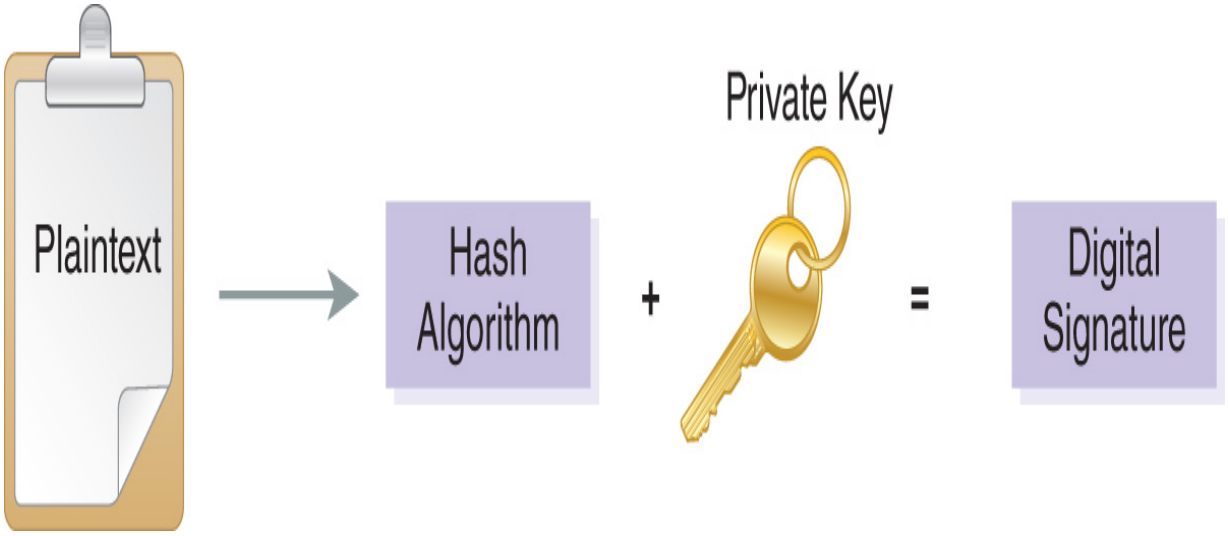


FIGURE 7-5 A digital signature.

You can construct a digital signature with a private key from an asymmetric key pair. It includes signing a hash of the message. This combination provides dual assurance: that a message originated from a particular entity and that no one has changed the contents. Anyone with access to a signer's public key can verify the digital signature. However, only the holder of the private key can create the digital signature. **FIGURE 7-6** shows how a digital signature operates. The digital signature is the encrypted version (using the sender's private key) of a digest (hash function

output) of the original message. This digital signature is then sent to the receiver, along with the message, and the receiver then decrypts the digital signature (using the sender's public key) and calculates a hash of the received message. If the calculated hash matches the decrypted digital signature, the message is authentic.

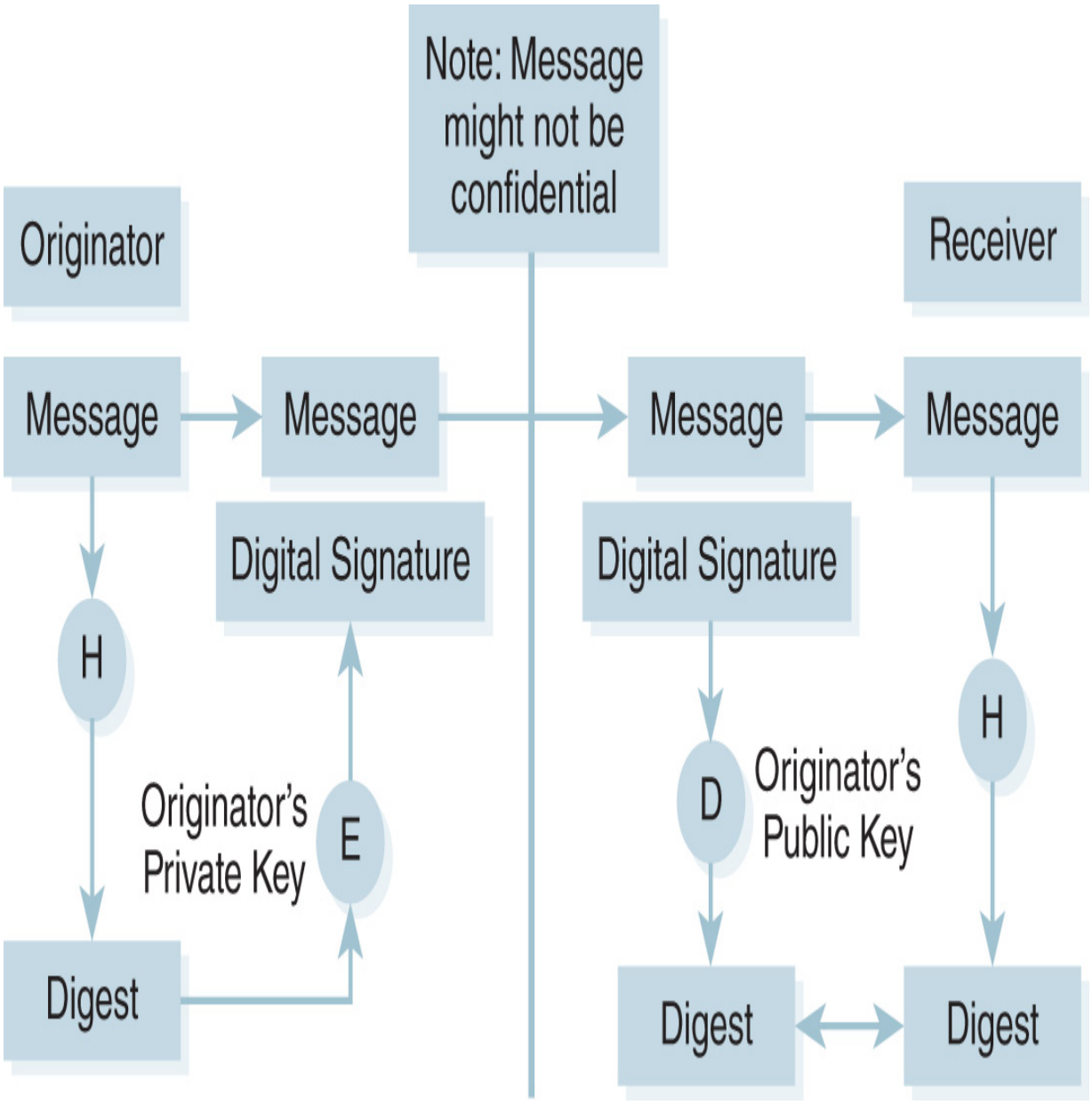


FIGURE 7-6 Operation of a digital signature. H = hash, E = encrypt, and D = decrypt.

The Rivest–Shamir–Adelman (RSA) algorithm and the Digital Signature Algorithm (DSA) are the most common digital signature algorithms used. The

patent on RSA expired in September 2000 so it is now in the public domain. The DSA signs the Secure Hash Algorithm (SHA) hash of the message. Although most commercial systems use RSA, the Digital Signature Standard (DSS), DSA, and SHA are U.S. government standards, so they are more likely to appear in government products.

Cryptographic Applications and Uses in Information System Security

Many vendors offer security products and services today, and, in fact, several thousand different offerings are available. These products and services are generally organized into common categories, which include the following:

- Anti-malware
- Compliance/auditing
- Forensics
- ID management
- Intellectual property
- Managed security service providers (MSSPs)
- Messaging safeguards
- Patch management
- Perimeter defenses
- Security information and event management (SIEM) and incident response
- Transaction security (e.g., digital certificates and secure file transfer)
- Wireless security
- Blockchain technology

You can find cryptography uses in many of these categories, but the last category is of special interest. Blockchain technology is one of the more recent applications that rely on cryptography. A blockchain is a data structure, often called a ledger, that is shared among multiple nodes and comprises a series of blocks that are linked, or chained, to one another. This technology uses cryptographic hashes to ensure integrity across all copies of the ledger. Blockchains that implement a public ledger, or ledger that is available to anyone, can provide a previously unattainable level of data transparency and integrity using cryptography.

Authentication tools include tokens, smart cards, biometrics, passwords, and password recovery. Some tools rely on proximity cards and fingerprint readers, and others use cryptographic techniques, such as PKI user authentication and tools that securely send passwords across the Internet. PKI is a set of hardware, software, people, policies, and procedures needed to create, manage, distribute, use, store, and revoke digital certificates.

Access control and authorization tools include firewalls, timestamping, single sign-on, identity management, and mobile device security, all of which have virtual private networks (VPNs) that may be included with firewalls but not necessarily the firewalls themselves. Moreover, they also may secure connectivity across the Internet and provide tools that encrypt contents of hard drives.

Assessment and auditing tools include vulnerability-assessment scanners, penetration-testing tools, forensic software, and log analyzers. Assessment scanners and penetration-testing tools that involve password-cracking modules use cryptographic techniques to try to guess passwords.

Security management products include tools for enterprise security management, configuration and patch management, and security policy development. Integrity-checking tools use cryptographic methods to make sure nothing and no one have modified the software.

Wireless security tools encrypt data to protect them in transit and to limit access to authorized people. Email security tools often involve encrypting data in transit and sometimes at rest. Content filtering includes antivirus products, mobile code scanners, web filters, and spam blockers, all of which typically do not use encryption, although databases of threat signatures may be encrypted.

Encryption tools include line encryption, database security products, VPNs, PKI, and crypto accelerators, all of which use cryptography extensively to do their tasks. A crypto accelerator offloads cryptographic routines from the main processor to cards that have chipsets designed for fast encryption.

Many traditional encryption ciphers are computationally expensive and require hefty processor support to operate in a usable timeframe. Many devices, such as smartphones, tablets, and Internet of Things (IoT) devices may lack the processing power to handle many cryptographic algorithm requirements. To address cryptographic needs on limited CPU devices,

lightweight cryptography includes algorithms designed for limited processing environments. Algorithms such as GOST 28147-89, CLEFIA, and Trivium can provide usable cryptography on limited devices. One class of lightweight cryptographic algorithms, called *low latency algorithms*, attempt to minimize the computation time to return a result to improve efficiency on low-power devices, such as IoT and mobile devices.

Other Cryptographic Tools and Resources

As a security professional, you should understand how to match business needs with cryptographic solutions and select proper tool sets. In this section, you will learn how to identify tool sets that use symmetric keys and match them to their most common business use, and how to identify tool sets that can use asymmetric key cryptography and the infrastructure required to make a solution. You will learn how hash functions work, how to identify the ciphers used for hash functions, and how to use them to ensure integrity. You will read about how to use cryptography to address each issue as well as the differences between each requirement. We will cover the differences between digital and digitized signatures and the infrastructure and legal requirements for maintaining digital signatures used for nonrepudiation. Finally, you will learn how to design a key management model that supports an organization's requirements.

Symmetric Key Standards

Symmetric key algorithms (or standards) are the most common form of encryption. In these algorithms, the same key encrypts and decrypts information. Because symmetric keys can be created easily and changed rapidly, they often are used just once to exchange information between two parties and then discarded. In this situation, they are session keys. Unlike asymmetric key algorithms, symmetric algorithms can be fast and are well suited to encrypting lots of data. The following list of cryptographic algorithms is sorted generally from weakest to strongest. Stronger algorithms are always more secure than weak algorithms but often have a higher computational cost; therefore, if a weaker algorithm provides sufficient security, it may be a better choice. Of course, you must periodically review

your algorithm choices to ensure that each one provides enough security if needs change. Organizations currently use several symmetric algorithms, including the following:

- **Data Encryption Standard (DES)**—IBM originally developed DES as the Lucifer algorithm, after which the NSA modified it and issued it as a national standard in 1977 and FIPS PUB 46-3 updated its definition. DES, now in the public domain, uses a 56-bit key, operates on 64-bit blocks of data, is better for hardware use than for software, and can rapidly encrypt multitudes of data. Once a state-of-the-art algorithm, rapid advances in hardware capabilities and attack methods have rendered it capable of being cracked in as little as a few days.
- **Triple DES (3DES)**—Triple DES is a protocol that consists of three passes of DES (i.e., encrypt, decrypt, and encrypt) using multiple keys, a process that increases the keyspace from 56 to 112, or 168 bits, depending on whether two or three keys are used. Triple DES is computationally secure because of the underlying security of the DES algorithm and the vastly increased keyspace. Note that using the same key three times produces the same result as the single DES. It too is contained in FIPS PUB 46-3 and is in the public domain.
- **International Data Encryption Algorithm (IDEA)**—Like DES, this block cipher operates on 64-bit blocks and uses a 128-bit key, both of which help it run somewhat faster than DES on hardware and software. Ascom-Tech AG holds a patent for IDEA (U.S. patent 5,214,703), but it is free for noncommercial use.
- **CAST**—The CAST algorithm is a substitution–permutation algorithm similar to DES. Unlike DES, its authors made its design criteria public. This 64-bit symmetric block cipher can use keys from 40 to 256 bits. RFC 2144 describes CAST-128, and RFC-2612 describes CAST-256. Although it is patented (U.S. patent 5,511,123), its inventors, C. M. Adams and S. E. Tavares, made it available for free use.
- **Blowfish**—Blowfish is a 64-bit block cipher that has a variable key length from 32 to 448 bits and is much faster than DES or IDEA. Blowfish is a strong algorithm and has been included in more than 150 products as well as in v2.5.47 of the Linux kernel. Its author, Bruce

Schneier, placed it in the public domain. Schneier's Twofish was a candidate for the Advanced Encryption Standard.

- **Advanced Encryption Standard (AES)**—Also known as Rijndael (RAIN-doll), AES is a strong and fast block cipher designed by Vincent Rijmen and Joan Daemen, and published as a standard by FIPS PUB 197. The AES algorithm can use cryptographic keys of 128, 192, and 256 bits to encrypt and decrypt data in blocks of 128 bits and can also operate on variable block lengths.
- **RC2**—RC2 is a variable key-size block cipher designed by Ronald Rivest (RC stands for Ron's Code) and owned by RSA Security. RC2 operates on 64-bit blocks and is a drop-in replacement for DES. Moreover, it uses a salt value as part of its encryption routine to make cryptanalysis more difficult.
- **RC4**—Produced by RSA Security, RC4 is a variable key-size stream cipher with byte- oriented operations and is often used by Internet browsers to provide an SSL connection.

FYI

To help defend against dictionary attacks in which attackers try common key values, some algorithms use an additional value called a **salt value**, which is a set of random characters that can be combined with an actual input key to create an encryption key. The combination of the salt value and the input key makes an encryption key far more difficult to compromise using common key values.

Wireless Security

With inexpensive high-bandwidth communications technology, wireless local area networks (WLANs) now are a viable strategy for homes and offices that do not want to link cable to all computers. WLANs are common in coffee shops and many other public areas. However, this convenience reduces security.

Many wireless access point providers and users install their new technology in a plug-and-play fashion; that is, they open the box, connect the pieces, turn the device on, and run the installation wizards. If it works, they never touch the manual. Although wireless products have built-in security, the default configuration generally does not enable it. Why? Because most consumers expect a product to work when they plug it in. As a result, most vendors that offer security require the customer to turn it on, but, because many customers never bother, this major security problem can be created.

802.11 Wireless Security.

The 802.11, or Wi-Fi, wireless standards emerged in 1999. Wi-Fi provides wireless communications at transmission speeds from 11 Mbps for 802.11b to over 780 Mbps for 802.11ac. New and proposed standards push the maximum transfer rate even further, with the 802.11ay standard supporting data transmission rates up to 100 Gbps. Moreover, the most popular standards within the 802.11 specification transmit data using either the 2.4 GHz or 5 GHz band and expand the bandwidth to about 100 meters (over 200 meters for 802.11n). Nevertheless, hackers have used high-gain antennas (including one made from a Pringles® potato chip can) to boost reception to several miles. A sort of informal competition is underway worldwide to see who can create the longest 802.11 wireless connection. At last count, the Swedish Space Corporation posted the record with a stratospheric balloon floating at a height of 29.7 km and achieving a connection with a base station 310 km away.

The 802.11 wireless protocols allow encryption through Wired Equivalent Privacy (WEP) or the newer Wi-Fi Protected Access (WPA). Users need to have a shared secret that serves as the key to begin secure wireless connections. Because most wireless access points (WAPs) generally do not enable wireless encryption by default, most wireless networks operate with no encryption at all, making these networks open to any attacker's monitoring and accessing. In 2000, Peter Shipley drove around the San Francisco Bay Area with a portable wireless rig. He found that about 85 percent of wireless networks were unencrypted. Of those that were encrypted, more than half used the default password. Although each WAP has its own service set identifier (SSID), which a client needs to know for access, hackers have tools, such as NetStumbler, that display the names of all SSIDs within range.

Windows simply connects to the first available network signal. As a result, wireless encryption is a minimum requirement to ensure security on a wireless network.

WARNING

The important lesson to remember is that wireless signals do not stop at a building's perimeter. Therefore, cryptographic protection becomes important to secure an organization's wireless communications.

WEP was the first wireless encryption protocol in widespread use; however, it has some severe limitations. Design flaws exist in the protocol, including key scheduling weaknesses in the RC4 encryption, whereby a hacker, using tools such as AirSnort or WEPcrack, can guess the encryption key after collecting approximately 5 million to 10 million encrypted packets. To address these weaknesses, current standards and supported hardware also offer WPA, which has three successively more secure versions: WPA; its successor, WPA2; and its newest and most secure protocols, WPA3. To provide the best protection for wireless network traffic, always use the latest WPA protocol and never use WEP; enable MAC address filtering, which screens out PCs that it does not recognize; and place a firewall between the wireless LAN and the rest of the network so that would-be attackers cannot get far.

Asymmetric Key Solutions

Recall that key distribution issues keys to valid users of a cryptosystem so they can communicate, but the first step in managing keys actually occurs before distributing them. Users must be authenticated and authorized for key creation and management through a registration process, which ensures that only authorized users can create keys in the first place. The classic solution to distributing keys in advance is to use out-of-band communications through a trusted channel, which could be registered mail; courier; or even a

telephone, if it has been verified that no one is tapping the phone lines. However, this strategy is expensive and slow.

Organizations with the resources and the ability to plan develop ways to distribute keys. For example, the U.S. Navy uses a unique distribution system, called the Communications Security Material System, or CMS, which includes strict accountability and control procedures to ensure proper use of cryptosystems. Each command appoints a CMS custodian and an alternate who are responsible for getting, storing, controlling, installing, removing, and destroying keys for navy cryptosystems. This procedure involves a lot of overhead and expense but is justified because of the high value of the information.

An asymmetric key distribution system has no need for couriers, back channels, or expensive storage or inventory plans because it does not require each party to first share a secret key, which solves the chicken-and-egg problem of first needing a secure channel before creating a secure channel.

Key revocation occurs when someone is no longer trusted or allowed to use a cryptosystem. In a symmetric key system, where everyone shares the same secret, compromising one copy of the key compromises all copies, a situation that is like all employees having the same office key. If a terminated employee refuses to return the key, the organization must change every lock and issue new keys. After a few dismissals, this process becomes expensive and cumbersome.

In an asymmetric key environment, the key directory is a trusted repository of all public keys. If one person is no longer trusted, the directory's manager removes that public key; therefore, no one attempting to initiate communications with that person would be able to find that key. That person would still be able to initiate encrypted communications by using other posted public keys. However, if the protocol requires digital signatures for all messages, the recipient would reject the message because it would not be able to find a valid key to check the signature. For example, you can query the MIT PGP Public Key Server at *http://pgp.mit.edu/*. But what happens if the entity that stores the keys ceases to exist? In the current era of outsourcing data and processing to cloud service providers, this is always a real possibility. A key escrow is a key storage method that allows some authorized third party access to a key under certain circumstances. Such

circumstances could include emergency situations when the key owner cannot access a key.

Ad hoc secure communications, one of the most frequently used forms of cryptography today, are the basis of e-commerce. Using a symmetric key would be difficult because it would require each party to make contact some way and agree on a secret key. If such a channel existed, why not just use that? Practically speaking, such a channel does not exist.

With an asymmetric key, ad hoc communications are straightforward. The most common form of Internet cryptography is SSL, or its successor, TLS, or Hypertext Transport Protocol Secure (HTTPS) encryption. The SSL handshake created the first secure communications session between a client and a server. For an explanation of this process, refer to the DigiCert website at *www.websecurity.digicert.com/security-topics/how-does-ssl-handshake-work* .

The SSL Handshake Protocol consists of two phases: server authentication and an optional client authentication. In the first phase, the server, in response to a client's request, sends its certificate—containing the server's public key—and its cipher preferences. The client then creates a master key, which is then encrypted with the server's public key. The client then sends the encrypted master key to the server, which recovers the master key and authenticates itself to the client by returning a message with the master key. The client and server encrypt and authenticate subsequent data with keys derived from this master key. In the optional second phase, the server sends a challenge to the client, and the client authenticates itself to the server by returning the client's digital signature on the challenge as well as its public key certificate.

Digital signatures verify a person's identity or that person's association with a message and require the use of a certificate authority (CA) that can vouch for the validity of a credential. The CA organization relies on **trust** and always starts with a root certificate, which is a certificate from an originally trusted CA. These trusted CAs normally originate from an operating system or software manufacturer, such as Microsoft, Apple, Google, or Mozilla. These root CAs sign other CA certificates to create intermediate CAs, which are the ones that issue the certificates we commonly use. Because an intermediate CA is trusted by a root CA, it can pass its trust to another CA and create a linked chain of trust called *certificate chaining*.

Whenever software runs that requests a digital certificate, the request goes to a registration authority, which is a trusted server that validates requests and instructs a CA to issue the digital certificate, each of which contains a set of certificate attributes that define the certificate. These attributes include the Common Name (CN), which is the server name the certificate protects; the Subject Alternative Name (SAN), which can contain a list of servers to allow a certificate to protect a group of servers; and the expiration date and time when the certificate is no longer valid.

Keeping the root CA safe from attack is extremely important because, if a root CA is compromised, every certificate it issued and every certificate that depended on its trust must be reissued. Such an undertaking would require an enormous amount of effort and represents a worst-case scenario for an environment that relies on certificates.

One way to protect a root CA from attack is to keep it offline, but there are trade-offs when comparing online versus offline CA management. Although keeping any CA offline is safer, it stops that CA from managing its certificate revocation list because the only way to revoke a CA would be to boot the CA, add revoked certificates to the revocation list, distribute the list, and then take the CA back offline. There are approaches that offload the revocation list management to another server, but, regardless, the CA must be brought online periodically to synchronize the revocation list and for other maintenance actions. Suffice it to say, keeping certificate statuses current is a prerequisite of maintaining trust. To address efficient revocation handling, the presenter of a certificate can attach the revocation status of the request to the certificate, a process referred to as *stapling*. To limit the risk of counterfeit certificates, certificate requests can also include a predefined list of valid certificates, called certificate *pinning*. Pinning reduces the flexibility of which certificates will be accepted to increase security.

One common use of certificates is to enforce nonrepudiation, which verifies the digital signature on a document to prove who sent a message. In some cases, certificates can be combined with a tamperproof time source to prove when the message was sent. But CAs do more than just provide certificates; they also provide a full suite of important certificate management functions, which include two critical services—users requesting certificates and the CA revoking certificates. A user can request a certificate by sending a standard certification signing request (CSR). A CSR standard allows many

types of programs to request certificates from a CA. At some point, most certificates either expire or become invalid. A CA maintains a list of invalid, or revoked, certificates in either a certificate revocation list (CRL) or by maintaining the data to support the newer Online Certificate Status Protocol (OCSP).

Hash Function and Integrity

You should be able to explain in layman's terms how hash functions work, identify the ciphers used for hash functions, and explain their use in ensuring integrity.

Hash Functions

Hash functions help detect forgeries by computing a checksum of a message and then combining it with a cryptographic function so that the result is tamperproof. Hashes are usually of a known fixed size based on the algorithm used.

Recall that a checksum is a one-way calculation that yields a result that you can check easily by rerunning the data through the checksum function. For example, given a series of decimal numbers, such as the following, a simple checksum could be the two rightmost digits of the sum of these numbers:

71 77 61 114 107 75 61 114 100 121

Therefore, in this case, you can add them together to get 901, drop the 9, and the checksum is 01. Now, if you were to send this sequence of 10 numbers to someone over a noisy communications channel, the noise could garble some of the information. By also sending the checksum, the recipient can recalculate to see whether the numbers add up. If not, the recipient knows to request a retransmission.

Because checksums are very simple functions, it is possible to have the checksum come out correctly on a garbled message. Of course, it's also possible for someone to deliberately modify the numbers in such a way that the checksum still matches, which illustrates the point that checksums do not ensure security; they ensure reliability.

A hash is a checksum designed so that no one can forge a message in a way that will result in the same hash as a legitimate message. The result is a hash value. In general, hash values are larger than checksum values. Hashes

act as a fingerprint of the data. You can make hashes available as a reference so that recipients can see whether the information has changed. Software publishers often provide hash values so that customers can verify the integrity of the software they receive. To be effective, hashes usually have to be long enough that a hacker would need a long time to create an alternate message that matched the hash value.

Professor Ronald Rivest of MIT (the R in RSA) developed the MD5 message digest algorithm. RFC 1321 contains the specifications for the algorithm. It takes an input of any arbitrary length and generates a 128-bit message digest that is computationally infeasible to match by finding another input. This message digest is uniquely associated with its source. You can publish an MD5 hash with information such as compiled source code and then compare the information with the hash. This verifies that no person or process, such as a virus, has modified the information.

Note, however, that the MD5 message digest is not yet a signed hash and that nothing uniquely associates the hash with the originator. That is, if an attacker wanted to modify a program, the attacker could easily recalculate a new MD5 hash and post both together on the website. The presence of an MD5 hash does not prove authenticity of a file; it proves only that the file has not changed since you computed the hash.

The Federal Information Processing Standard Publication 180-1 (FIPS 180-1) defines the Secure Hash Algorithm (SHA-1). SHA-1 produces a 160-bit hash from a message of any arbitrary length. Like MD5, it creates a unique fingerprint of a file that is computationally infeasible to reproduce. SHA-1 was so popular that it resulted in developments that produced two additional standards, SHA-2 and SHA-3. Each successive version increases the options for input size and output length. MD5 and SHA are not the only hashing algorithms, though. The hash message authentication code (HMAC) is a hash function that uses a key to create the hash, or message digest. RACE Integrity Primitives Evaluation Message Digest (RIPEMD) is a collection of functions that provide hash values for a wide range of applications.

How do you create a digital signature from a hash? The output from the MD5 or the SHA hash provides input for an asymmetric key algorithm that uses a private key as input. The result of this encryption is a value that is uniquely associated with the file. It is computationally infeasible to forge and

provably relate to the identity of the entity that signs the file. FIPS 180-1 includes the diagram in **FIGURE 7-7** that shows this relationship.

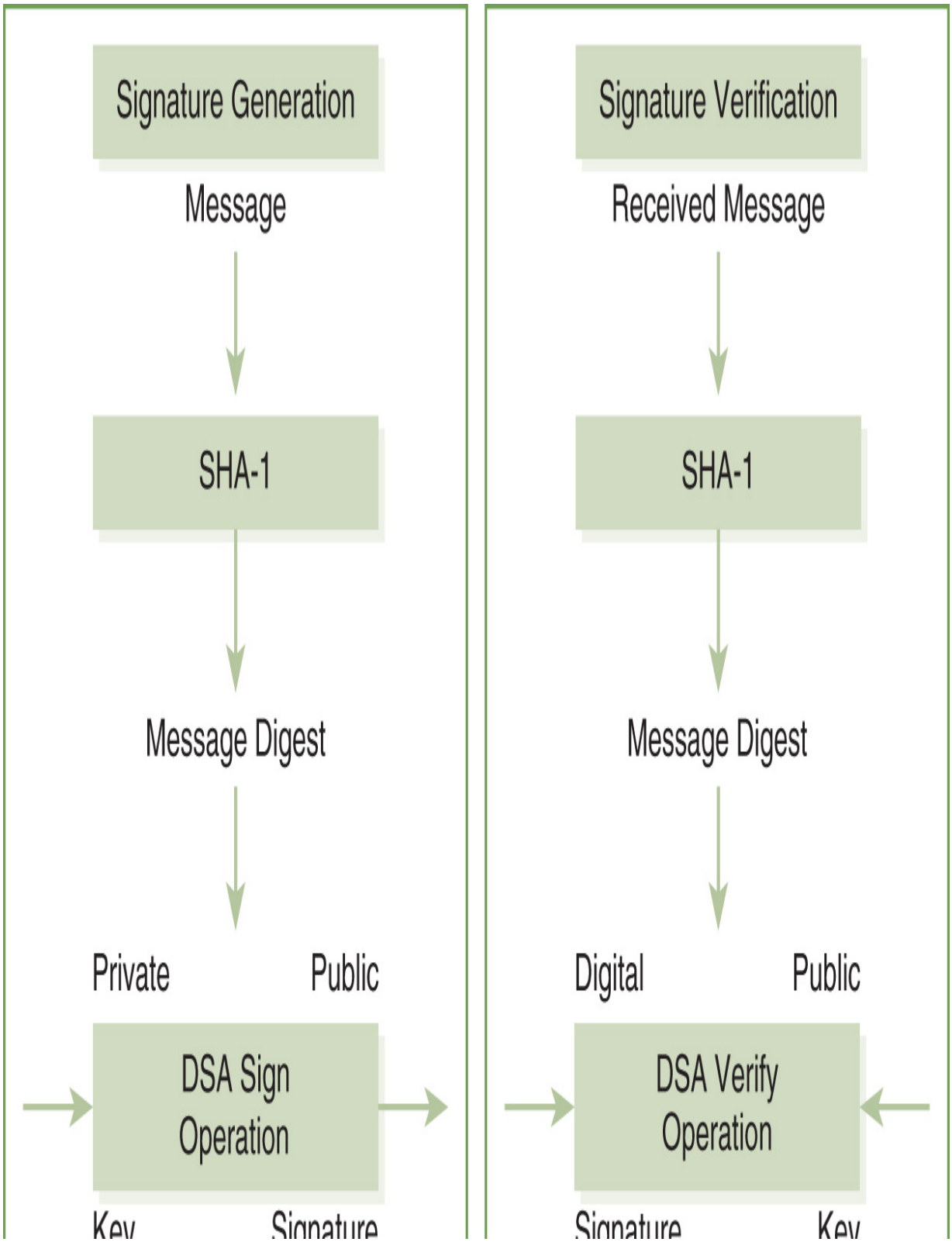


FIGURE 7-7 Relationship between hash and digital signature algorithms.

Someone can digitally sign a message, software, or any other digital representation in a way that anyone can easily verify. Note that this presumes the integrity of the public key directory that the recipient uses to look up the key to verify the signature. If an attacker successfully penetrates the directory, all bets are off. At that point, the fox is vouching for the safety of the henhouse.

There are several software packages to make implementing encryption a little easier, two of the most popular being PGP/GPG and bcrypt. Pretty Good Privacy (PGP) is a program originally written by Phil Zimmerman that provides encryption for data communications and is most often used for protecting email messages. GNU Privacy Guard (GPG) is a freely available alternative to PGP. GPG is commonly used in applications that cannot justify PGP licenses. Another common software application that provides cryptography services is bcrypt, an application that derives keys from user passwords. It is used in many applications that require passwords that change based on a user's identity. Password-Based Key Derivation Function 2 (PBKDF2) is another software application that helps to derive cryptographic keys. BPKDF2 is part of RSA Laboratory's Public-Key Cryptography Standards (PKCS).

Digital Signatures and Nonrepudiation

Given a sample business case, you should understand how to state, in layman's terms, the differences between digital and digitized signatures and be able to explain the infrastructure and legal needs for keeping digital signatures for nonrepudiation.

Digital Signatures Versus Digitized Signatures

Earlier in the chapter, you learned about digital signatures and digitized signatures. Although the difference between the two is straightforward, many people often confuse them. To review, a digitized signature is an image of a physical signature stored in digital format. This file could be in JPG, GIF, or BMP format and, theoretically, stored in a digital camera. The chief value of a digitized signature is printing it onto form letters, sometimes in a different color, to make it look more like a handwritten ink signature on the printed page.

A digital signature is something quite different. Recall that a digital signature is a combination of a strong hash of a message, which acts as a fingerprint. This can be combined with a secret key from either a symmetric or an asymmetric cryptosystem. This combination gives dual assurance that a message originated from a particular entity and that no one has altered the contents.

In an asymmetric cryptosystem, anyone with access to a signer's public key can verify the digital signature. However, only the holder of the private key can create it. In a symmetric cryptosystem, both sender and recipient need the same secret key.

Think about this: Which security principle can you satisfy with an asymmetric digital signature but not a symmetric one? The answer is nonrepudiation. If both sender and recipient have the same secret key, you cannot prove to someone else that a message exchange started with one party rather than the other. Therefore, the conditions for proving nonrepudiation are as follows:

- An effective asymmetric key algorithm
- A strong hash function
- A means to apply the private encryption key to the hash value to produce a digital signature

- A tamperproof or trusted third-party timing device, if desired
- An agreed-upon protocol for validating digital signatures
- A secure key management and distribution system
- A public key repository that has an assured level of integrity
- Key escrow to be able to produce public keys from reluctant parties
- Procedures to handle disputes

Organizations must spell out all these steps in writing as part of a business agreement. Then, and only then, is it ready to implement nonrepudiation.

Principles of Certificates and Key Management

You learned about key management earlier in the chapter, that it includes creating, distributing, storing, validating, updating, replacing, and revoking keys and keying material.

Here is a sample classic key management scheme. The Enigma was one of the most famous cryptographic devices of the 20th century. Invented by Arthur Scherbius, it was Germany's chief encryption tool before and during World War II. The machine had more possible keying configurations than the number of atoms in the known universe. In practice, a subset of keys was used to make key changing practical. Nonetheless, the three-rotor Enigma offered a dizzying 158,962,555,217,826,360,000 possible keys at the beginning of World War II.

German Enigma operators got a new codebook monthly. This book told which key to use each day. Now, if all messages were encrypted with that same key, Allied cryptanalysts would have a lot of ciphertext, all encrypted with the same key, to attempt to decrypt, which could be a problem. Therefore, the keying protocol required that only the key in the codebook be used as a key-encrypting key. The wartime Enigma had five scramblers, of which its users employed only three at any time. Users could place each of those scrambler wheels in one of 26 starting positions—one for each letter of the alphabet. Therefore, every message began with the setting of the scramblers. Senders repeated each message to make sure the key got through any radio interference. With 60 different possible scrambler selections and $26 \times 26 \times 26$, or 17,576, possible starting positions, users could encrypt each day's messages with one of 1,054,560 possible keys. Note that, without knowing the initial settings, the cryptanalyst still did not know which of the 159 quintillion keys to use. The Enigma encryption was totally unbreakable, right? The Germans thought so, but they were wrong.

Polish cryptographer Marian Rejewski figured it out. There's not enough space to go into detail here about how he did it, but you can look up his exploits in a number of books. It's enough to say here that his solution involved a brilliant use of pure mathematics to exploit a weakness in the

cipher. The moral of the story is that a key distribution system may appear secure and the number of keys nearly infinite. However, the best key management system in the world does not protect against a brilliant cryptanalyst if the encryption algorithm itself has any weaknesses.

Modern Key Management Techniques

Today, computers handle all business cryptography. Some of the best minds in the field have scrutinized the algorithms of choice, sometimes for decades. Therefore, an attacker most likely will not defeat an organization's cryptography by breaking the mathematics behind it. Human behavior—and, most important, human error—is much more likely to lead to the compromise, and poor key management is often the cause.

This is not the place to examine the technical complexities of each key management technique. Instead, you will look at which techniques are right for different business applications. For example, PKI is a technology that absolutely requires effective key management, and PKI vendors have promised tremendous growth for years. However, the practicality of using all the key management components has throttled growth. The rest of this section contains a brief overview of several modern key management techniques. Use this discussion as a starting point to decide which technique works best for an organization.

One of the most important aspects of implementing any key management strategy is trust. You have to trust someone. Otherwise, you would not accept any credentials as valid. The most common trust model is often called the "web of trust." This term refers to a model in which any entity determines who it will trust initially. This is often decided through direct interrogation and authorization. Once an entity is trusted, the organization trusts other organizations that the trusted entity trusts. In other words, "I trust whoever you trust." This model works well when all trusted entities are actually trustworthy. The other model is to require that every entity provide proof of trustworthiness before trust is extended. The web-of-trust model is far easier to implement, but it does allow for abuse because any untrustworthy entity can trick any other node in the web into trusting it.

AES

The U.S. government currently has no standard for creating cryptographic keys for unclassified applications. However, working groups have been defining an AES key wrap specification that would securely encrypt a plaintext key along with integrity information. This capability would provide a mechanism for key management in unclassified government environments.

IPSec

IPSec protects Internet Protocol (IP) packets from disclosure or change. The protocol provides privacy and/or integrity. Each header contains a security parameter index (SPI) that refers to a particular encryption key. Additionally, the header may contain up to two security headers. The Authentication Header (AH) provides integrity checking, and the encapsulating security payload (ESP) encrypts the packet for confidentiality. Hosts using IPSec establish a security association with each other, which involves agreeing which crypto methods and keys to use as well as the SPI host. The Internet Security Association and Key Management Protocol (ISAKMP, pronounced *ICE-a-camp*) provides key management services, which you will learn about next.

ISAKMP

ISAKMP is an increasingly popular key management strategy. RFC 2408 defines ISAKMP as a set of procedures for authenticating a communicating peer and creating and managing security associations, key generation techniques, and threat mitigation, that is, denial of service and replay attacks. All these are necessary to establish and maintain secure communications via IP Security Service or any other security protocol in an Internet environment.

The security association (SA), which is the basic element of ISAKMP key management, contains all the information needed to perform a variety of network security services. ISAKMP acts as a common framework for agreeing to the format of SA attributes and for negotiating, modifying, and deleting SAs; it uses a Diffie–Hellman key exchange signed with RSA.

XKMS

The Extensible Markup Language (XML) key management specification (XKMS) gives protocols for distributing and registering public keys for use with XML, which is a markup language for documents containing structured

information. It provides syntax that supports sharing complex structured documents over the web.

Managed PKI

Some vendors offer a managed service to handle issues associated with public key management. Services include centralized key generation, distribution, backup, and recovery. Rather than create a key management infrastructure, customers can choose to outsource these details.

ANSI X9.17

The financial industry created this standard to define key management procedures. It defines a symmetric key exchange protocol that many manufacturers use in hardware encryption devices. Although asymmetric key exchange offers some advantages, the fact that organizations have invested significant amounts of money in X9.17-compliant equipment means they will continue to use it for some time. According to FIPS Pub 171, X9.17 specifies the minimum standards for the following:

- Control of the keying material during its lifetime to prevent unauthorized disclosure, modification, or substitution
- Distribution of the keying material in order to permit interoperability between cryptographic equipment or facilities
- Ensuring the integrity of keying material during all phases of its life, including its generation, distribution, storage, entry, use, and destruction
- Recovery in the event of a failure of the key management process or when the integrity of the keying material is questioned

When you select a key management product or technique for your organization, do your homework first. Each method has its advantages and disadvantages. Make sure you understand the up-front cost as well as the ongoing maintenance and administration costs.

CHAPTER SUMMARY

In this chapter, you learned how cryptography works and how it applies to solving business issues. You learned key cryptographic terms and business principles, how to apply cryptography to these principles, and how to identify security tools that rely on cryptography. You also learned the advantages and disadvantages of symmetric and asymmetric ciphers as they pertain to cryptanalysis and how quantum cryptography is changing the world of network security.

KEY CONCEPTS AND TERMS

Algorithm
Asymmetric key cryptography
Checksum
Cipher
Ciphertext
Cryptanalysis
Cryptography
Cryptosystem
Decryption
Digital signature
Encryption
Hash
Key
Key distribution
Key management
Keyspace
Nonrepudiation
Plaintext
Private (symmetric) key
Public (asymmetric) key
Public key cryptography
Quantum cryptography
Substitution cipher
Symmetric key cryptography
Transposition cipher
Trust

CHAPTER 7 ASSESSMENT

1. _____ offers a mechanism to accomplish four security goals: confidentiality, integrity, authentication, and nonrepudiation.

   A. Security association (SA)

   B. Transport Layer Security (TLS)

   C. Cryptography

   D. None of the above

2. A strong hash function is designed so that it is nearly impossible for a forged message to result in the same hash as a legitimate message.

   A. True

   B. False

3. The act of scrambling plaintext into ciphertext is known as _____.

   A. Decryption

   B. Encryption

   C. Plaintext

   D. Cleartext

4. An algorithm used for cryptographic purposes is known as a _____.

   A. Hash

   B. Private key

   C. Public key

   D. Cipher

5. Encryption ciphers fall into two general categories: symmetric (private) key and asymmetric (public) key.

   A. True

B. False

6. An encryption cipher that uses the same key to encrypt and decrypt is called a(n) _____ key.

A. Symmetric (private)

B. Asymmetric (public)

C. Encrypting

D. Hash

E. None of the above

7. _____ corroborates the identity of an entity, whether the sender, the sender's computer, some device, or some information.

A. Nonrepudiation

B. Confidentiality

C. Integrity

D. Authentication

8. Which of the following is one of the four basic forms of a cryptographic attack?

A. Ciphertext-only attack

B. Known-plaintext attack

C. Chosen-plaintext attack

D. Chosen-ciphertext attack

E. All the above

9. The two basic types of ciphers are transposition and substitution.

A. True

B. False

10. A _____ is used to detect malicious changes to data.

A. Hash function

B. Checksum

C. Hash value

D. KDC

11. DES, IDEA, RC4, and WPA are examples of _____.

A. Key revocation

B. 802.11b wireless security

C. Asymmetric key algorithms (or standards)

D. Symmetric algorithms (or standards)

12. A _____signature is a representation of a physical signature stored in a digital format.

A. Digital

B. Digitized

C. Private key

D. Public key

CHAPTER 8
Malicious Software and Attack Vectors

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MALICIOUS SOFTWARE IS a threat to every Internet-connected device. Attackers know they can use specially crafted software or networking vulnerabilities to compromise systems and wreak havoc. In this chapter, you will learn how **malicious software** operates, how attackers use it, and how you can combat it. Simply put, malicious software is any program that carries out actions that the computer user does not intend. Often, the goal of malicious software is to cause harm to a system, data, or reputation. Malicious software moves through the Internet much as a snake slithers through grass. Attackers use malicious software, or **malware**, to steal passwords, steal confidential information, delete information from a system (or encrypt it), or even reformat storage devices. Unfortunately, malicious code cannot be controlled with antivirus software alone because malicious code includes more than just viruses and some malware evades detection very well.

Malicious code attacks all three information security properties:

- **Confidentiality**—Malware can disclose an organization's private information or the private information of personnel. In this chapter, you will learn how spyware and Trojans, which are other forms of malware, can capture private and proprietary information and send it to unauthorized destinations.
- **Integrity**—Either immediately or over a period of time, malware can modify data that lives in files and databases or even as it travels through the network. By the time the changed data is discovered, the malware may have also corrupted backups. It is important to verify the integrity

of all data any time a security breach is suspected, which is a potentially expensive process that likely was not budgeted for.

- **Availability**—Malware can erase or overwrite files or inflict considerable damage to storage media. Some types of malware even render information unusable without deleting or destroying it.

As a security professional, you will find it a challenge to convince your organization's personnel that data security is everyone's responsibility. They tend to think the responsibility lies only with the security department. Not only that, but they also tend to think that security efforts get in the way of their work. These security efforts include the policies, procedures, and technologies that are necessary to prevent malware attacks. Because many data breaches involve some type of malware, protecting an organization from all types of malware makes its systems more resistant to large-scale data breaches.

Chapter 8 Topics

This chapter covers the following topics and concepts:

- What malware is and how it inflicts harm on an organization's systems
- What the main types of malware are
- What the history of malicious code is
- How malware is a threat to business organizations
- What motivates attackers and types of attacks
- What tools and techniques prevent attacks
- What tools and techniques detect attacks

Chapter 8 Goals

When you complete this chapter, you will be able to:

- Define malicious software and activity

- Define types of malware, such as a Trojan, a virus, a worm, spyware, adware, and ransomware
- Understand malicious software risks and threats to individuals
- Understand malicious software risks and threats to businesses
- Understand the phases of a malicious software attack
- Understand attack-prevention tools and techniques
- Understand incident-detection tools and techniques

Characteristics, Architecture, and Operations of Malicious Software

Malicious software, or malware, is any program that contains instructions that run on a computer system and perform operations that the user does not intend, and security professionals know well how dangerous it can be. This activity can take several forms:

- An attacker gains administrative control of a system and uses commands to inflict harm.
- An attacker sends commands directly to a system. The system interprets these commands as valid and then executes them.
- An attacker uses software programs that harm a system or make the data unusable. These programs can come from physical media (e.g., a USB drive) or a communications process (e.g., the Internet). A malicious flash drive is a popular way to spread malware of all types because it so easy to do. All the attacker needs to do is drop some flash drives that are infected with malware, and, when a victim finds one and inserts it in his or her computer, the computer gets infected. Malicious USB cables can also distribute malware to an unsuspecting victim's device. Instead of just getting a battery charge from a USB cable, an attacker may be using the data connections in the cable to download malware as well. Examples of these types of malicious software programs are viruses, Trojan programs, and worms.
- An attacker uses legitimate remote administration tools and security probes to identify and exploit security vulnerabilities in a network.

Malware can include infected files of known and wanted programs as well as potentially unwanted programs (PUPs), which are those that get installed without the user's knowledge or awareness. Awareness of the kinds of malicious code threats that may be encountered is mandatory for every security professional. This understanding will help a security professional develop reasonable countermeasures to protect an organization.

The Main Types of Malware

Most computer users refer to any **malicious code** as a virus when, in fact, there are several types of viruses, as well as many other forms of malicious code, each of which has unique characteristics and architecture and requires different approaches to defend against it. You must design and implement effective countermeasures to detect, mitigate, and prevent a range of malicious code attacks, and, to do this, you must develop an understanding of various types of malicious code and how each type is used. Malware is a favorite tool of cybercriminals because it can provide unprecedented access to a victim's computing systems and data. In fact, many attacks in which the attackers compromise a resource and stay undetected for a long period of time (i.e., advanced persistent threats [APTs]) start with malware.

In this section, you will learn how to recognize and describe the characteristics and operation of common types of malicious code and how attackers use each type, information that is necessary to understand how to implement appropriate countermeasures.

Viruses

Although many types of malware are commonly referred to as viruses, only some types can be properly classified in this manner. A computer **virus** is an executable program that attaches itself to, or infects, other executable programs and then replicates to infect other programs. Some viruses also perform destructive activities after they replicate. These types of viruses are made up of executable instructions that infect and replicate, called the *virus operational segment*, and the executable instructions that carry out its intent, called the *payload*. Good anti-malware controls can detect and possibly eliminate most viruses that contain an obvious or damaging payload. The primary characteristic of a virus is that it replicates and generally involves user action of some type. Not all viruses carry a payload that inflicts harm; some are just annoying or focus on replicating. Other viruses hide their payload and install a backdoor. A **backdoor** is a hidden way to bypass

access controls and allow access to a system or resource. Therefore, the victim may not notice the virus or may not immediately notice its damage.

Evidence of Virus Code Activities

Although you may not always identify every virus, viruses have many telltale signs. Any of the following may indicate an infected computer or device:

- Deteriorating workstation, server, or device responsiveness
- Unexpected and sustained disk activity levels (churning)
- Sudden sluggishness of user applications or services, particularly at startup
- Unexplained freezing of applications or unexpected error messages
- Unscheduled resets and crashes, including program aborts
- Sudden antivirus alarm activity
- Disk error messages, including increased “lost cluster” results from disk scanning
- Unexplained decrease in available space on disk or available memory
- In the case of macro viruses, saved documents that open as DOT files
- Applications (or their icons) that disappear or will not execute

There are three primary types of viruses: system infectors, file infectors, and data infectors. System infectors are viruses that target computer and device hardware and software startup functions, file infectors are viruses that attack and modify executable programs (such as COM, EXE, SYS, and DLL files in Microsoft Windows), and data infectors are viruses that attack document files containing embedded macro programming capabilities.

WARNING

Do not forget that malware can attack any computing device, including smartphones, tablets, and all types of Internet of Things (IoT) devices. As odd as it sounds, your smart refrigerator or washing machine could be infected as well as your doorbell. Malware actions may occur interactively in real-time sessions between an attacker and the target, or, alternatively, malware may lie dormant and trigger at some predetermined time or when some predictable event occurs. The result may be to initiate a destructive action or to simply observe, collect information, and send the information to a controller. **FIGURE 8-1** shows the typical life cycle of a computer virus.

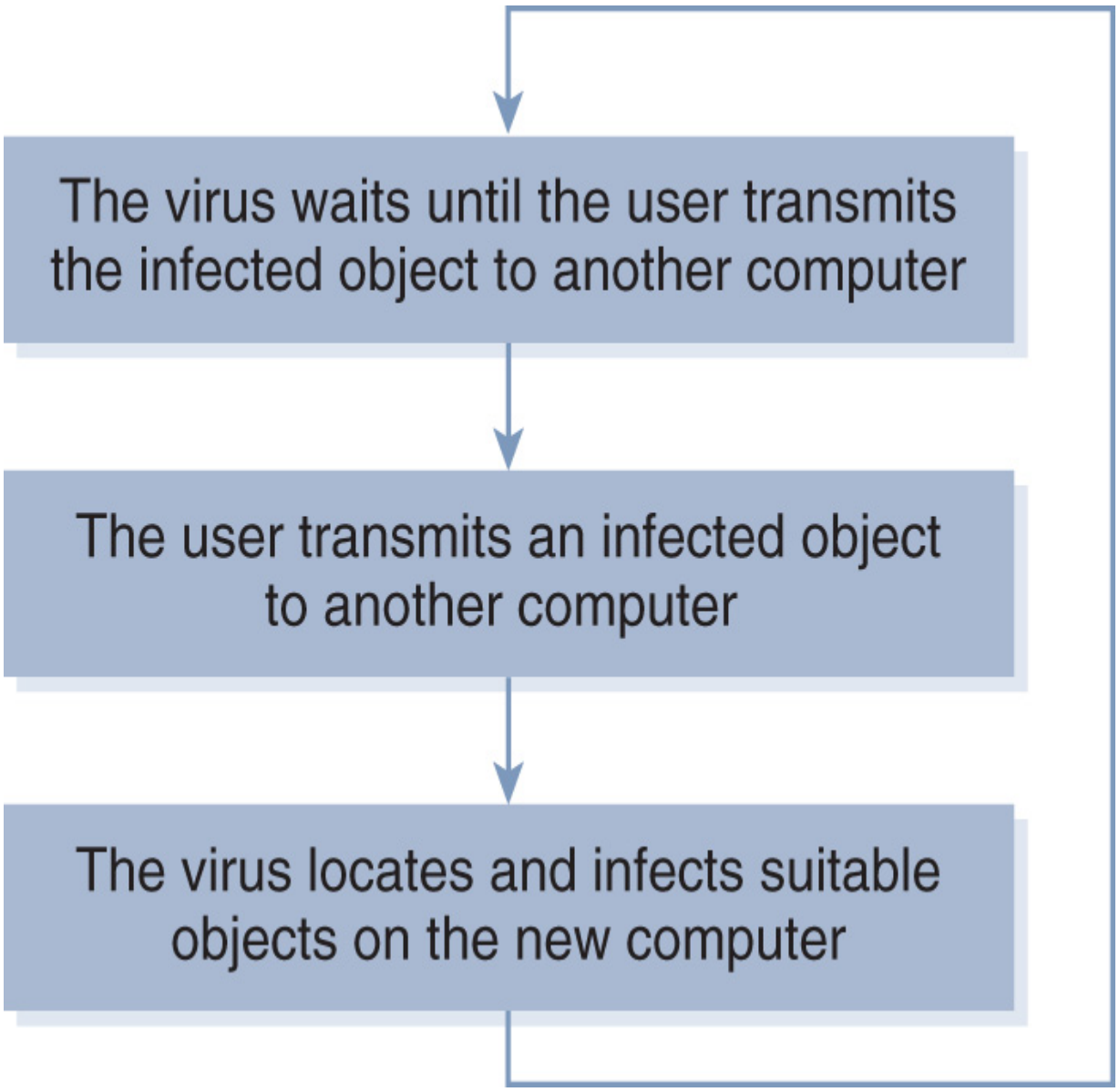

The virus waits until the user transmits the infected object to another computer
The user transmits an infected object to another computer
The virus locates and infects suitable objects on the new computer

FIGURE 8-1 Typical life cycle of a computer virus.

Boot Record Infectors

System infectors are viruses that target key hardware and system software components in a computer or device that usually is part of the system startup process. This type of infection enables the virus to take control and execute before the computer can load most protective controls. The most prevalent types of system infectors are boot device Master Boot Record infectors, which travel primarily through media exchange.

Master Boot Record and System Infectors

A Master Boot Record infector moves or destroys the original Master Boot Record of a boot device, replacing it with viral code, after which it can gain control from the bootstrap program and perform its hostile mission. Typically, Master Boot Record infectors perform their tasks and then return control to the legitimate Master Boot Record or the active partition boot record to mask their existence.

Both types of boot record infectors commonly load instructions that can bypass the ROM-based system services. Loading at this level allows the virus to intercept all normal application and operating system hardware requests, which include functions such as opening and closing files and file directory services. This type of virus can also execute other types of malicious code routines and cover its own tracks.

A virus with this dual-action capability is called a multipartite virus. It can subsequently execute file-infection code as well. **FIGURE 8-2** shows how a system infector virus affects a computer.

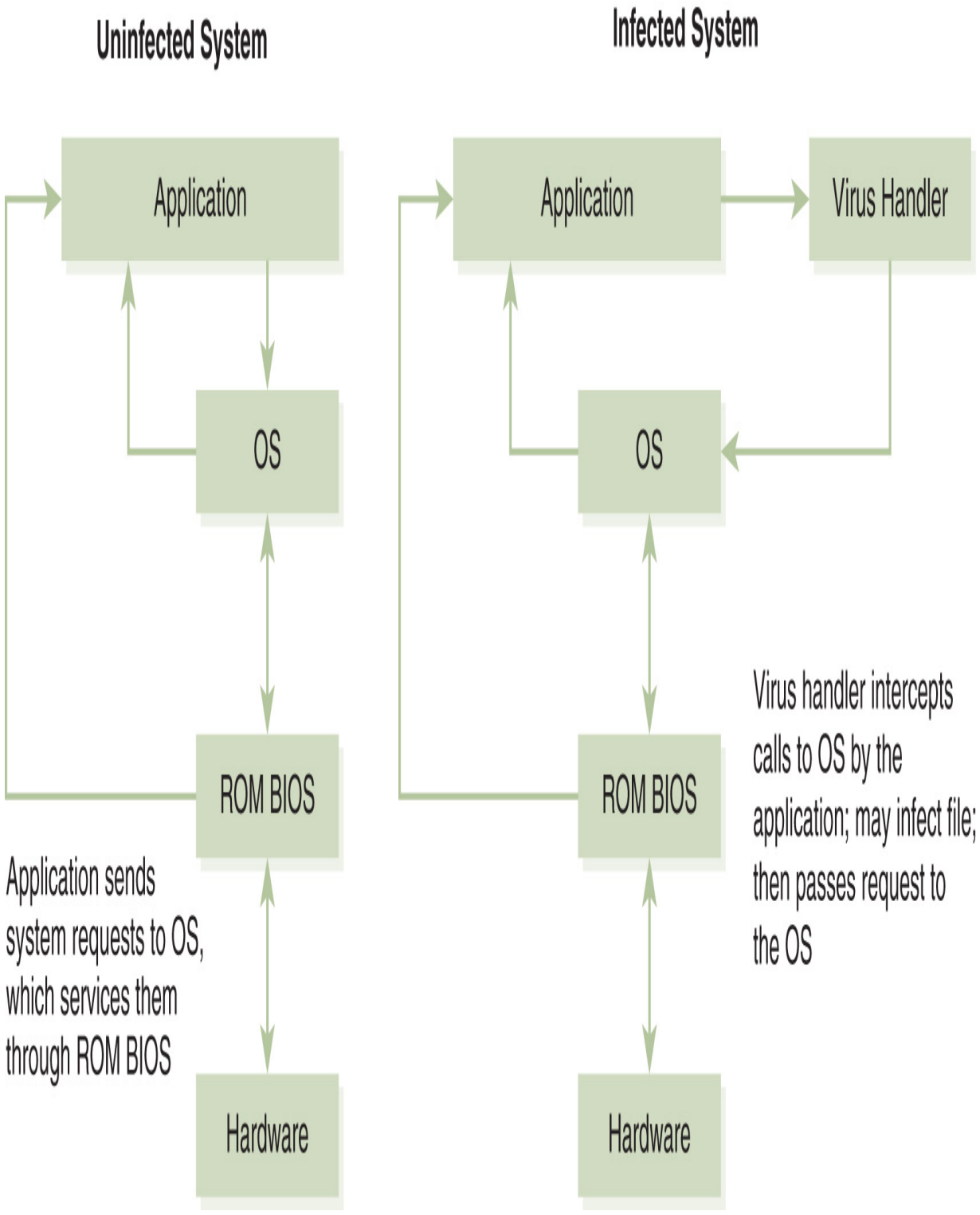


FIGURE 8-2 How a system infector virus works.

File (Program) Infectors

File infector viruses exhibit the classic "replicate and attach" behavior. Because of the wide acceptance and popularity of Microsoft Windows–based operating systems, most well-known file infectors target those systems. They typically attack program files with .com or .exe file extensions, but newer virus strains work well with SYS, DLL, and many other Windows file types.

Although Windows computers are common targets, computers and devices that run Linux, macOS, iOS, and Android are encountering a growing number of malware attacks. Moreover, the number of attacks on mobile and IoT devices is also growing rapidly as these devices become more common and because their owners do not always take the time to secure them. Broadcom publishes the annual *Internet Security Threat Report (ISTR)*, which contains a wealth of information and statistics on malware activities and recommended countermeasures.

Malware developers write and compile many of these viruses using high-level languages. C and C++ languages are common choices because of their ability to provide the power and flexibility viruses need to be successful along with easy access to the underlying hardware. In contrast, they often use assembly language to write boot record infectors. Although the coding of file infector viruses can be quite complex, the architecture of most executable programs is relatively straightforward. Viruses of this type attach themselves to the original program file, where they control the execution of that file until it can replicate and infect other files and possibly deliver a payload.

One type of file infector, a companion virus, is really a separate program file that does not attach itself to the original host program. Instead, it creates a new program with a matching filename but with an extension that executes earlier than the original. For example, Windows executes .com files before it executes .exe files. The virus creates this file in the same directory path as the real program so that, when the user runs the program, the operating system calls the malware instead of the legitimate program. After the virus finishes its work, it simply executes the command to start the original program. **FIGURE 8-3** shows how a file infector virus works.

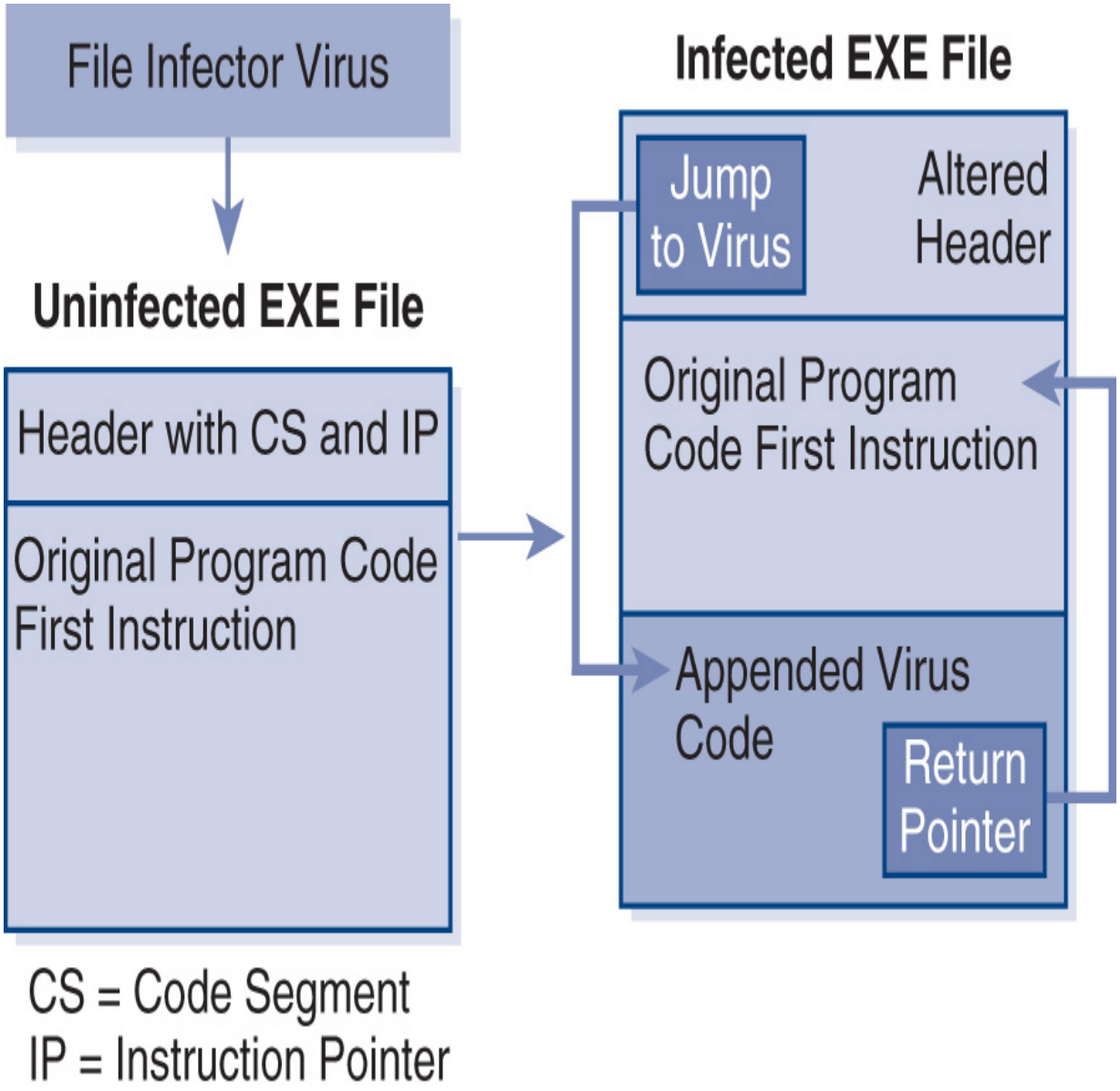


FIGURE 8-3 How a file infector virus works.

Macro (Data File) Infectors

Macro viruses became a problem when software vendors added recording capabilities, called macros, to popular office applications. Users use macro-recording capabilities to record their actions in a program. The application in which the actions are recorded stores these instructions with the data file. Users can then execute the actions automatically when they open the file or press a predefined keystroke sequence. The original purpose of macros was to automate repetitive processes. Users liked the feature because it made

applications more convenient and efficient. However, these macros opened the door for malicious code to carry out its own instructions.

Macro viruses infect these document files and insert their own commands so that, when users share the infected document with other users, the malware spreads and replicates. The connected nature of most office applications makes it easy for infected documents to spread to other computers and users. Macros can move easily between platforms, and they are quite simple to construct. For this reason, macro viruses are extremely popular among hackers.

The email bomb is a form of malicious macro attack, which typically involves an email attachment that contains macros designed to inflict maximum damage. One of the most effective ways to damage many documents is to infect a template or shared document that many other documents reference, an example of which is the normal.dot template, which most Microsoft Word documents include. Because the normal.dot template is so commonly used, it is sometimes referred to as a member of a global pool of common documents. A global macro pool infection attacks commonly shared documents. Attackers can send the document attachment through an anonymous remailer to reach its targets with great precision. Therefore, anyone who receives the email bomb need only open the attachment, and, in some cases, simply preview the email message to launch the macro virus and activate the email bomb. **FIGURE 8-4** shows how a macro virus works.

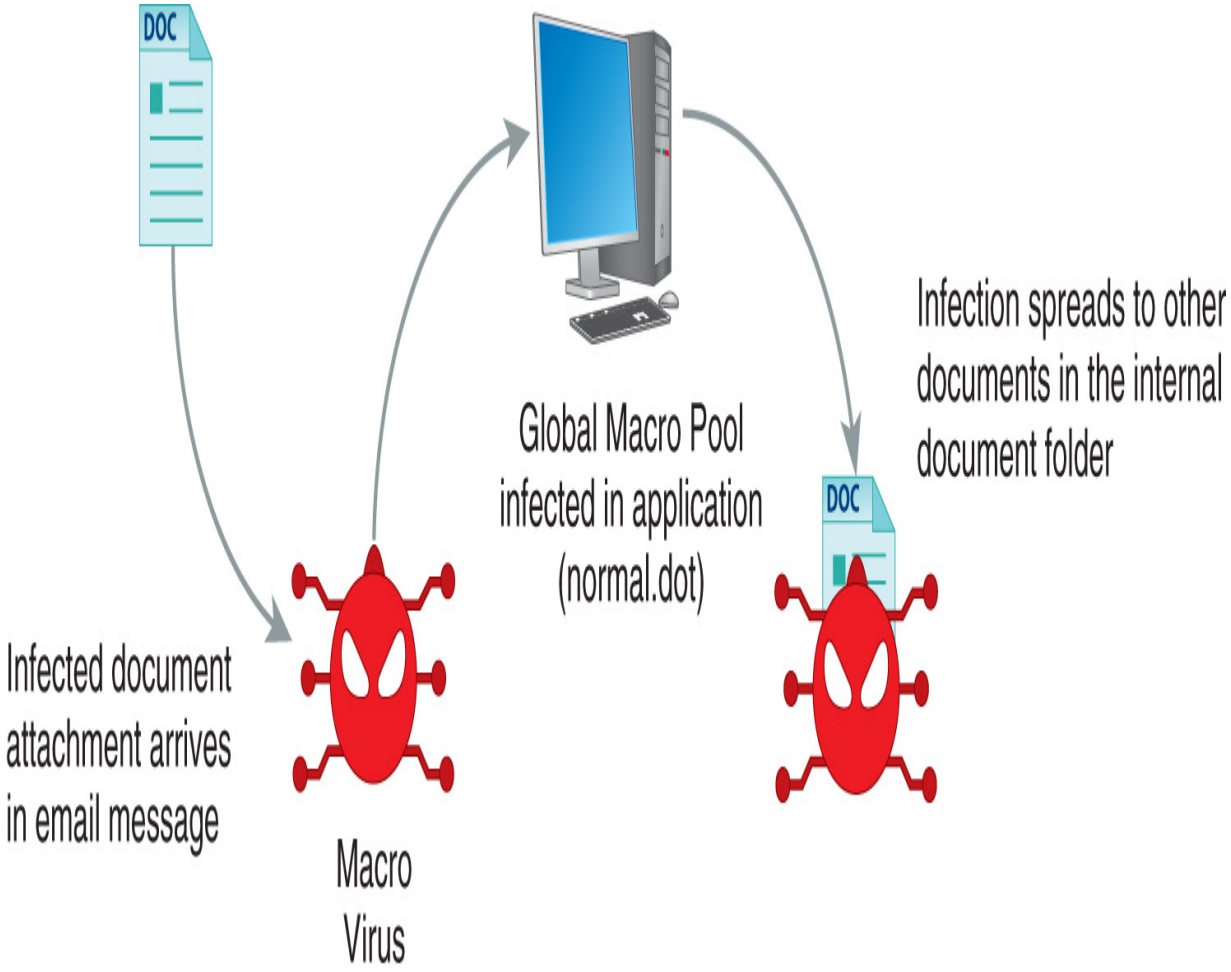

DOC
Infection spreads to other documents in the internal document folder
Global Macro Pool infected in application (normal.dot)
DOC
Infected document attachment arrives in email message
Macro Virus

FIGURE 8-4 How a macro virus works.

Other Virus Classifications

Viruses can use a number of techniques to propagate and avoid detection from antivirus software. Most single computer viruses work by copying exact replicas of themselves to each file, boot sector, or document they infect. The virus accomplishes subsequent infections in the same manner, making exact duplicates, byte for byte. This predictable action produces a signature pattern, which many antivirus and anti-malware programs look for to detect malware. Some viruses, though, such as the following, behave differently:

- **Polymorphic viruses**—Polymorphic viruses include a separate encryption engine that stores the payload in encrypted format while duplicating the body of the virus. The virus exposes only the decryption routine for possible detection, and embeds the operational segment of

the virus in the decryption routine, which seizes control of the target system and decrypts the payload of the virus so that it can execute. True polymorphic viruses use an additional mutation engine to vary the decryption process for each iteration, which makes this portion of the code even more difficult to identify. **FIGURE 8-5** shows how a polymorphic virus infects a computer.

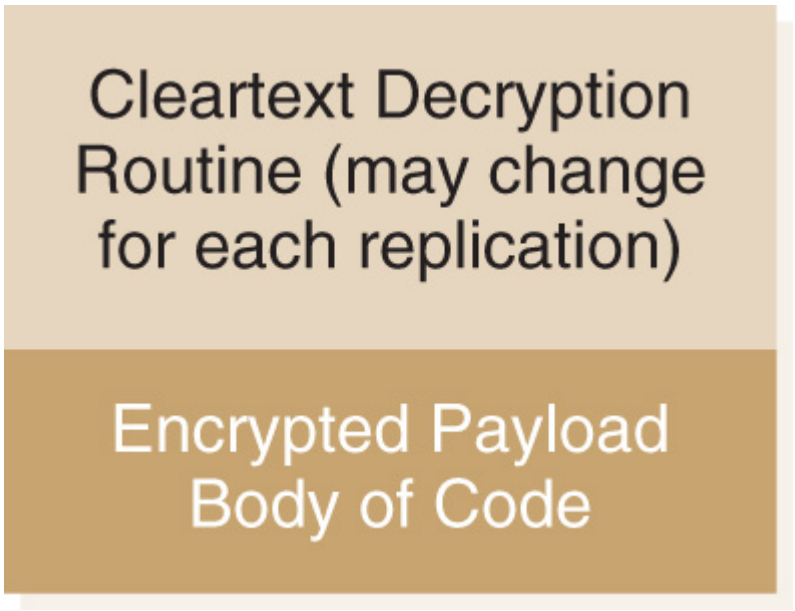


FIGURE 8-5 How a polymorphic virus works.

- **Stealth viruses**—Stealth viruses, also called armored viruses, use a number of techniques to conceal themselves from users and detection software and can have either size or read stealth or both. By installing a low-level system service function, they can intercept any system request, such as a task list request, and alter the service output to conceal their presence. **FIGURE 8-6** shows how a stealth/armored virus works.

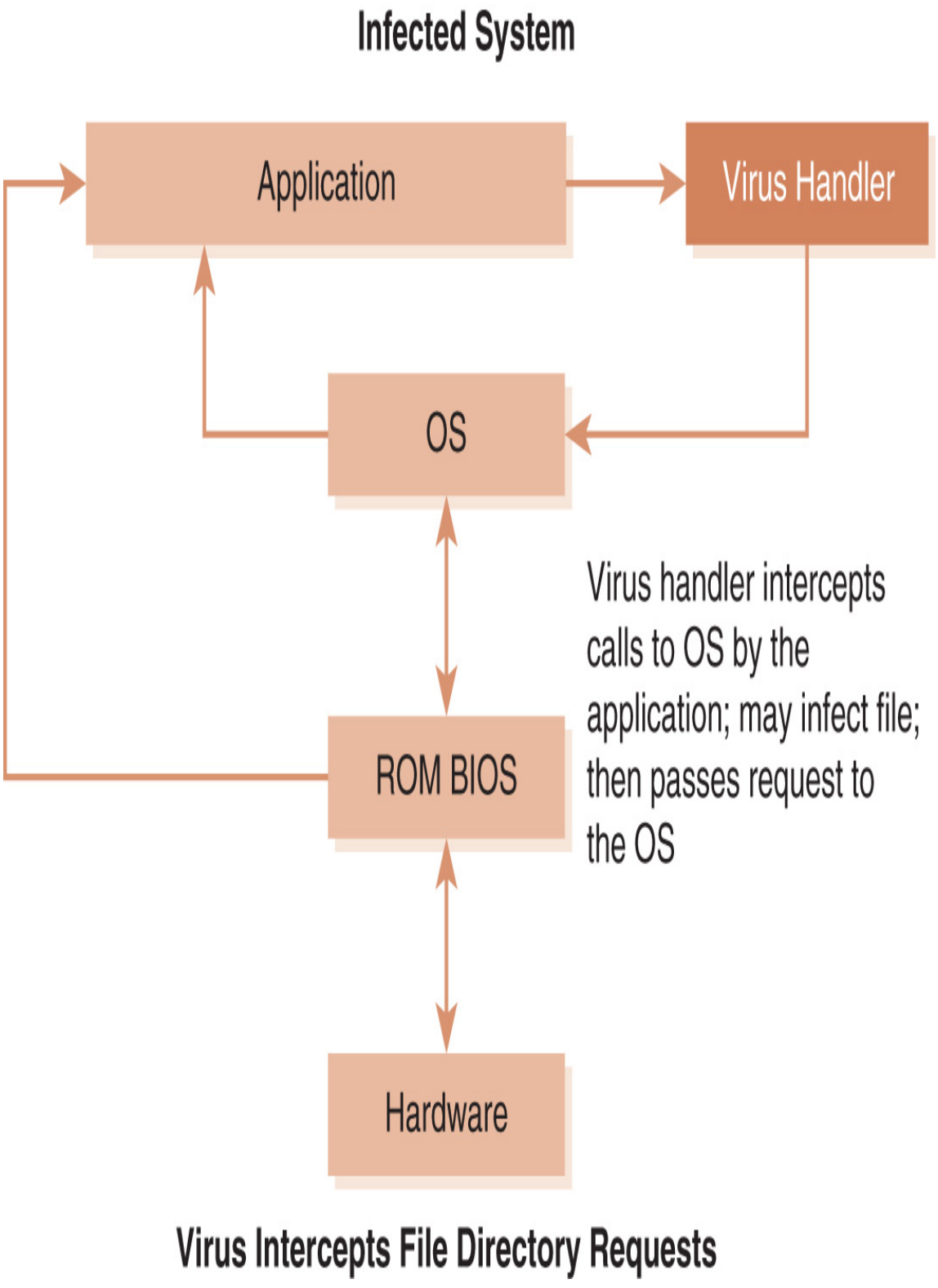

Infected System
Application
Virus Handler
OS
Virus handler intercepts calls to OS by the application; may infect file; then passes request to the OS
ROM BIOS
Hardware
Virus Intercepts File Directory Requests

FIGURE 8-6 How a stealth virus works.

- **Slow viruses**—Slow viruses, also called *fileless viruses*, counter the ability of antivirus programs to detect changes in infected files. This class of virus resides in only the computer's memory and not in a file, so antivirus software has a harder time detecting it. The virus waits for certain tasks, such as copying or moving files, to execute, and, as the operating system reads the file into memory, the virus alters data read from the input file before writing to the output file, making it much harder to detect. **FIGURE 8-7** shows how a slow virus works.

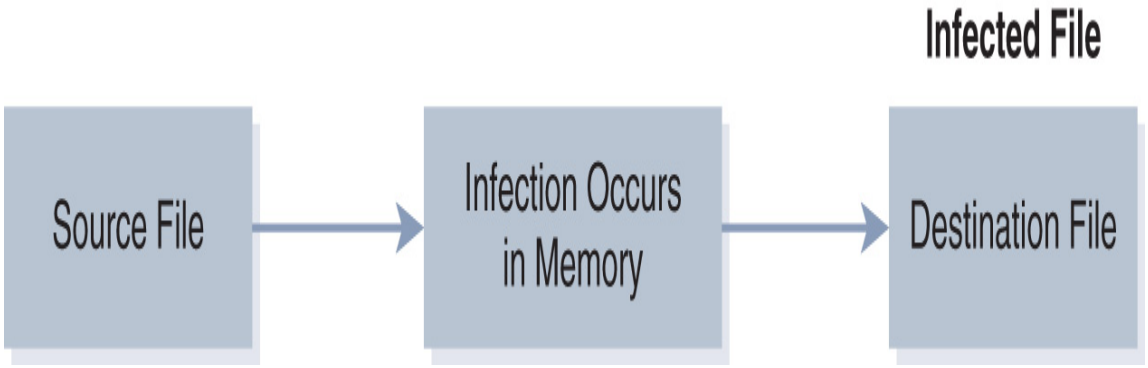


FIGURE 8-7 How a slow virus works.

- **Retro viruses**—Retro viruses attack countermeasures, such as antivirus signature files or integrity databases, by searching for these data files and deleting or altering them, thereby severely restricting the antivirus software's ability to function. Other viruses, especially boot viruses (which gain control of the target system at startup), modify Windows Registry keys and other operating system key startup files to disable antivirus/anti-malware, firewall, and intrusion detection system (IDS) software if found. **FIGURE 8-8** shows how a retro virus works.

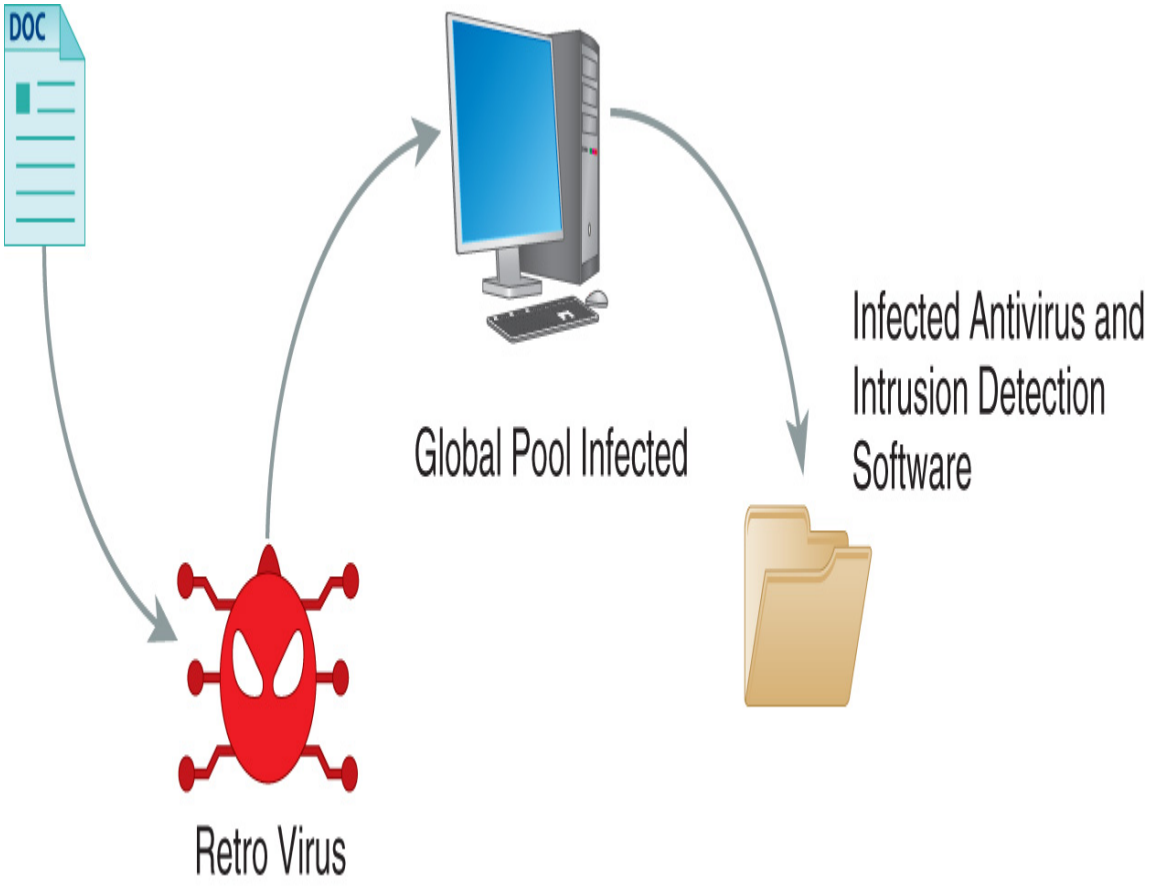


FIGURE 8-8 How a retro virus works.

- **Cross-platform viruses**—Cross-platform viruses are less prevalent but can still be potent threats. There have been a number of documented viruses that target multiple operating systems. If those platforms also run Windows emulation software, they become as susceptible to Windows viruses as a native Windows computer.
- **Multipartite viruses**—As previously mentioned, multipartite viruses are hybrid viruses that exhibit multiple behaviors. There are two main types of multipartite virus: Master Boot Record/boot sector viruses and file-infecting viruses. Such viruses may exist as file infectors within an application. Upon execution of the infected application, the virus might spawn a Master Boot Record infection, which then infects other files when the system is restarted. **FIGURE 8-9** shows how a multipartite virus works.

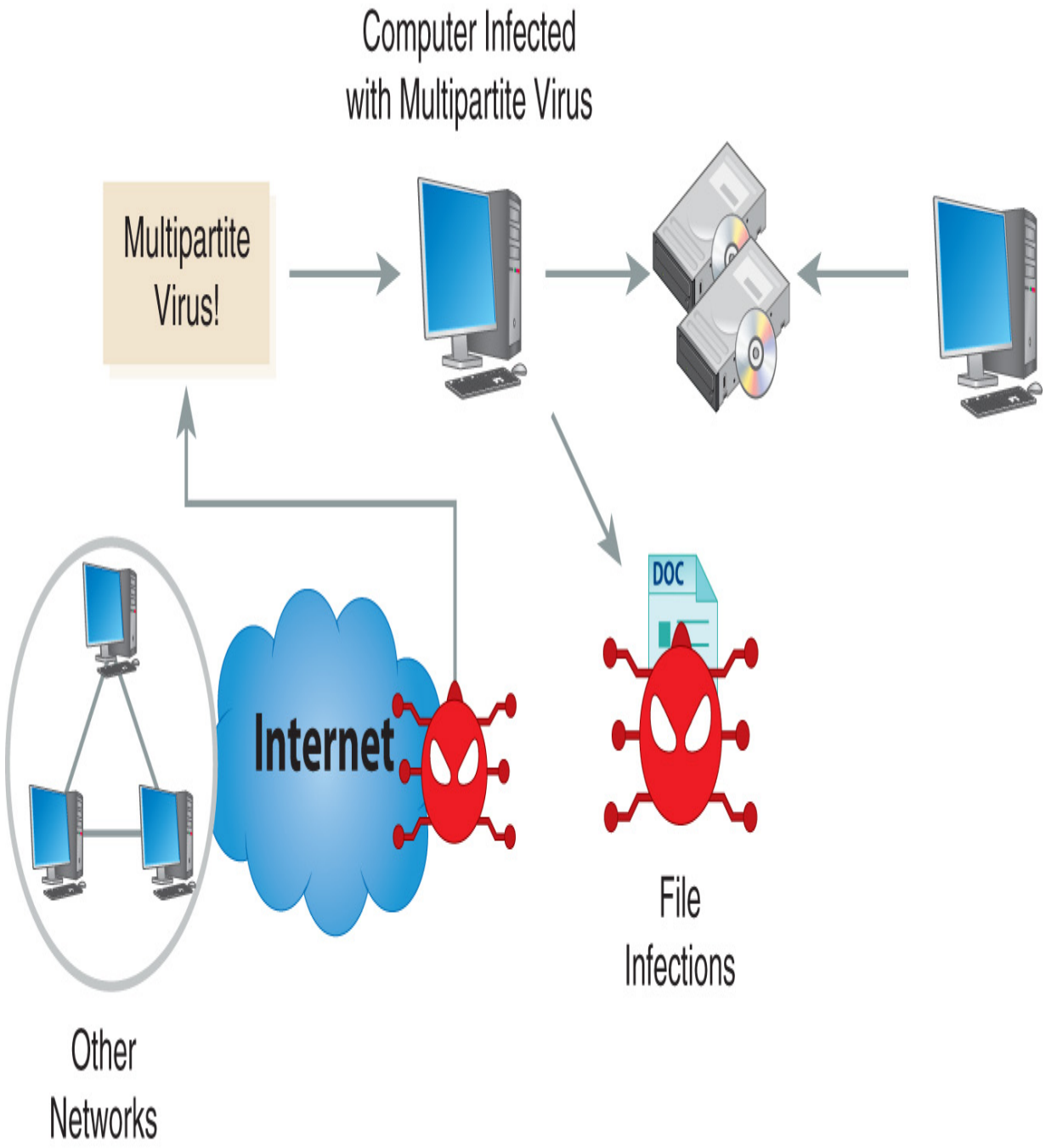


FIGURE 8-9 How a multipartite virus works.

Some multipartite viruses, such as the One Half virus, isolated in 1994, may also exhibit both stealth and polymorphic characteristics.

FYI

Size stealth hides the fact that an infected file is bigger than it used to be. The virus intercepts system requests for file information and subtracts its own size from the reply before passing it back to the requesting process. Read stealth hides the fact that the virus moved the boot sector code. The virus intercepts read/write requests for the normal boot sector, which the virus has relocated and replaced with the viral code. The virus redirects the request to the new hidden location of the original boot sector code.

Rootkits

A **rootkit** is a type of malware that modifies or replaces one or more existing programs to hide the fact that a computer has been compromised. It is common for rootkits to modify parts of the operating system to conceal traces of their presence. They can exist at any level, from the boot instructions of a computer up to the applications that run in the operating system. Once installed, rootkits provide attackers with access to compromised computers and easy access to launching additional attacks. Rootkits are newer than other types of malware and did not appear until around 1990. They can be very difficult to detect and remove since their main purpose is to hide their own existence, but identifying and removing rootkits is crucial to maintaining a secure system.

In 2015, reports began to emerge that described very serious types of rootkits. It was discovered that rootkits could be burned into the firmware of hard disk drives or even into a computer's Basic Input/Output System (BIOS). These rootkits would survive complete operating system reinstallation and hard drive reformatting. In the case of the BIOS rootkit, even replacing a disk drive with a completely new disk drive would not remove the rootkit. These newer types of rootkits are extremely pervasive and difficult to remove without substantial technical skill. In 2016, several sources reported that the U.S. National Security Agency (NSA) had used hard drive firmware rootkits to enable surveillance on specific targets.

Ransomware

Another type of malware attempts to generate funds directly from a computer user and is one of the fastest-growing menaces. **Ransomware** attacks a

computer or device and limits the user's ability to access important stored data, which it can do by slowing down the computer or device; denying access for authorized users; or blocking access to specific programs, services, or resources. Many current ransomware programs operate by encrypting important files or even the entire storage device and making them inaccessible.

One of the first ransomware programs was CryptoLocker, which was released in 2013, and since then these programs have become even more sophisticated and dangerous. The attacker generally alerts the users to the restrictions and demands a payment, or *ransom* (which gives this type of malware its name) to restore full access. The attacker promises to decrypt the user's data or remove any mechanisms that block access once the ransom is paid. Most computer users rely on their computers and the data they store. Therefore, few of them can lose access to their data and other resources without encountering ongoing frustration. For organizations, a successful ransomware attack could result in the loss of millions of dollars in recovery effort and revenue.

NOTE

So how can malware simply take control of a computer? It can use many different techniques, but two common ones depend on lazy programmers. A *buffer overflow* is a condition when a program allows more data to be loaded into a variable than it expected. When this happens, the "extra" data can change protected data in memory or even change a program's instructions. A similar weakness is an *integer overflow*, an arithmetic operation that results in a number that is too large to be stored in a simple integer variable. In both cases, programmers should handle the errors and alert the user because unhandled errors like these can make programs behave in unusual ways.

Business users may find ransomware to be far more than a simple annoyance in that the inability to access key parts of a business computing

environment can have the same effect as a denial of service (DoS) attack. Thus, a ransomware attack can cost an organization large sums of lost profits in a very short period of time. Attackers that launch ransomware attacks expose themselves to huge risks but also can realize large profits. User reliance on mobile devices and the proliferation of IoT makes such devices attractive targets. As computers and other devices become more mobile and autonomous, they become even more vulnerable to potential ransomware attacks.

Spam

Spam is one of the most bothersome challenges faced by network administrators. Not only does spam routinely contain viruses or other malware, but the volume of spam also congests networks and mail servers and can waste a lot of user time and productivity. Many viruses now carry software to make infected computers and devices part of a spam botnet. These spam botnets send out new versions of viruses that lead to an ever-present and growing problem. An equally troublesome variant of spam is spam over Internet messaging (spim), which, instead of using email to spread messages, uses instant messaging applications to send unwanted and sometimes malicious messages to a large number of users.

What Is Spam?

SPAM, in all uppercase letters, is a trademark of Hormel Foods. In mixed or lowercase letters, the term refers to unsolicited commercial email. The current use of the term *spam* originated in a Monty Python comedy skit, first televised in 1970, about a waiter in a diner where every dish included the product SPAM. Any time one of the characters uttered the word "SPAM," several Vikings in the diner repeatedly chanted "SPAM, SPAM, SPAM, SPAM!" The Vikings' chanting overwhelmed the main dialogue, making it difficult to understand the other characters. As a result, the term *spam* came to mean any noise or other excessive communication that overwhelms the main message.

Most anti-spam vendors estimate that 70 to 90 percent of all messaging traffic is spam, which, simply put, is any unwanted message. However, many users still open unwanted emails or receive unwanted text messages, instant messages, or social media messages. They see the promise of jobs, lottery winnings, or reduced prices on products, which makes it hard to classify the message as strictly "unwanted."

Spam is a recurring major problem for organizations of all sizes: it wastes employees' time and bandwidth that organizations need to operate; it is breeding grounds for malware of all types; and the messages that contain offensive content could expose the organization to financial liability. Fortunately, automated tools are available to assist the security administrator in eliminating these messages, but, unfortunately, spam generators are very dynamic and quickly change to avoid spam detection filters. Therefore, completely eliminating spam turns out to be very difficult.

Despite the increasing deployment of anti-spam services and technology, the number and size of spam messages continue to increase. Although not specifically malicious code, spam represents at least the following threats to organizations:

- Spam consumes computing resources (bandwidth and CPU time).
- Spam diverts IT personnel from activities more critical to network security.
- Spam messages are potential carriers of malware (e.g., viruses and hostile active content).
- Spammers have developed techniques to compromise intermediate systems to facilitate remailing services, masking the real source addresses and constituting a DoS attack for victimized systems.
- Opt-out (unsubscribe) features in spam messages can represent a new form of reconnaissance attack to acquire legitimate target addresses.

Worms

Worms are self-contained programs designed to propagate from one host machine to another using the host's own network communications protocols, but, unlike viruses, worms do not require a host program in order to survive

and replicate. Originally, the distinction between worms and viruses was that worms used networks and communications links to spread and did not directly attach to an executable file. The use of the term *worm* stems from the fact that worms are programs with segments working on different computers and all communicating over a network.

A worm usually probes network-attached computers to exploit a specific vulnerability. Generally, worms look for a specific piece of server or utility software that will respond to network queries or activity. Examples of worms include the Morris worm of 1988 (also called the Internet worm). Slightly more recent worms include Conficker, Stuxnet, Lovgate.F, Sobig.F, and WannaCry, along with a number of Linux worms, such as the L10n, Badbunny, and Darlloz worms. Blaster was possibly one of the most successful early worms because the function it used, DCOM, was available on all versions of Windows—desktop as well as server. **FIGURE 8-10** shows how a worm works.

Evidence of Worm Attacks

Worms leave many telltale signs of their presence. Any of the following may indicate an infected computer:

- Unexplained increases in bandwidth consumption
- High volumes of inbound and outbound email or other network traffic during normal activity periods
- Sudden increase in email server storage utilization (this may trigger alarm thresholds set to monitor and manage disk/user partition space)
- Unexplained decrease in available disk space
- Unusual increase in average message size or increase in volume of attachments
- Unexpected Simple Mail Transfer Protocol (SMTP) or Post Office Protocol 3 (POP3) daemon (background process) responses for nondelivery of message traffic that was not sent by users
- Sudden increase in user response times across the network or sudden congestion at chokepoints near server clusters

- Sudden increase in intrusion detection system/intrusion prevention system (IDS/IPS) and firewall threshold alarm activity

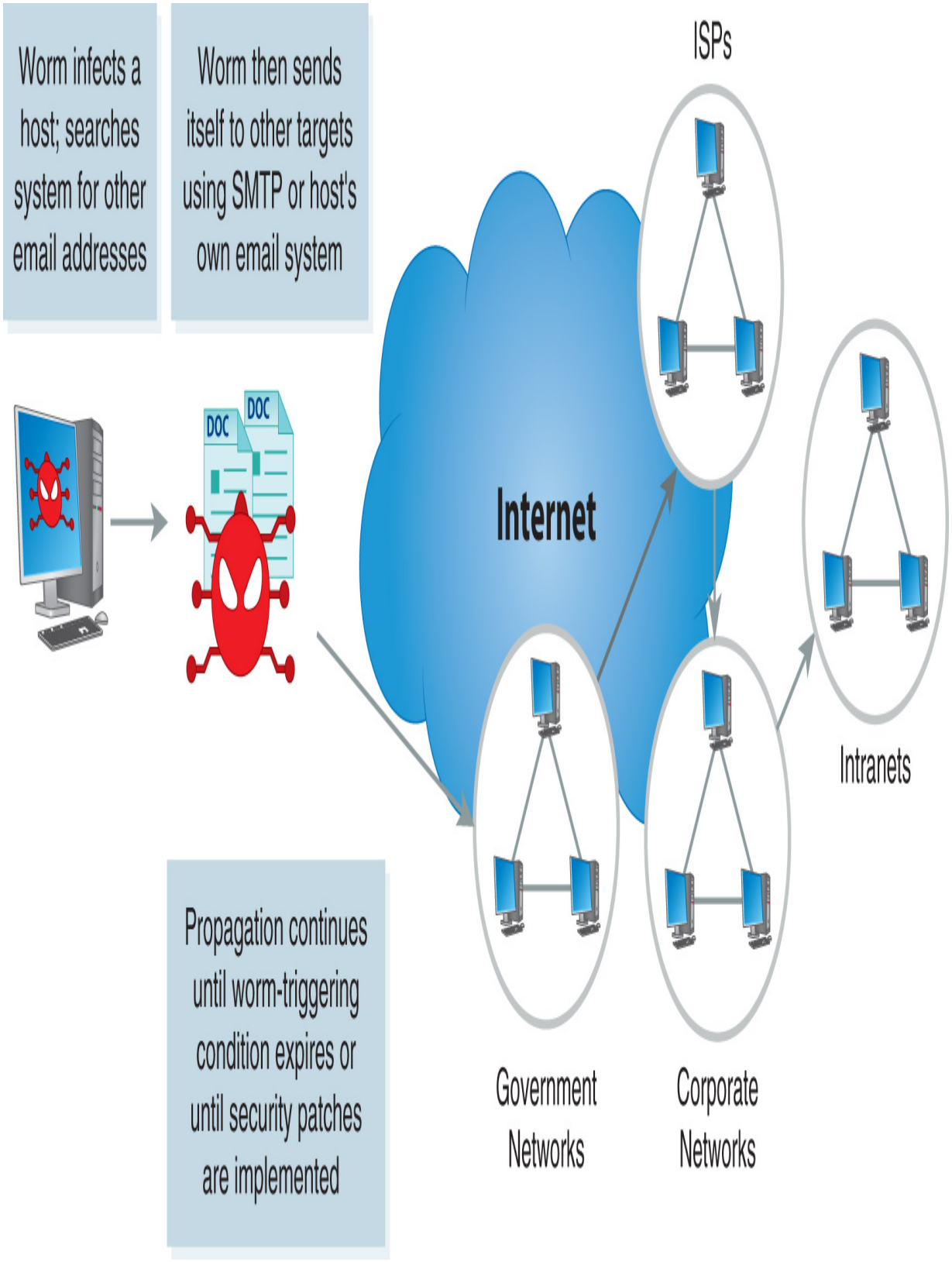

Worm infects a host; searches system for other email addresses
Worm then sends itself to other targets using SMTP or host's own email system
ISPs
DOC
DOC
Internet
Intranets
Propagation continues until worm-triggering condition expires or until security patches are implemented
Government Networks
Corporate Networks

FIGURE 8-10 How a worm works.

A worm may spread rapidly without any user action and often attacks server software, which is because many people who write worms know that servers are on all the time, allowing the worm to spread at a faster rate. However, servers are not the only places worms live. IoT devices are attractive targets because they are online and unattended much of the time.

Trojan Horses

Trojans, or Trojan horse programs, are the largest class of malware. A Trojan is any program that masquerades as a useful program while hiding its malicious intent. The masquerading nature of a Trojan encourages users to download and run the program. From the attacker's perspective, the advantage to this approach is that the Trojan runs as an authorized process because an authorized user ran it. The success of Trojans is due to their reliance on social engineering to spread and operate; they have to trick users into running them. If the Trojan appears to be a useful program, it has a better chance of being run and thus spreading. In fact, the most successful Trojans actually do provide useful services, and unwitting users may run the Trojan many times. However, each time the Trojan runs, it also carries out some unwanted action, just like any other type of malware.

Many Trojans spread through email messages, website downloads, or social media links. In years past, Trojan developers posted the programs on electronic bulletin board systems and file archive sites. Moderators and anti-malware software would soon identify and eliminate malicious programs. More recently, Trojan programs have spread by mass email, websites, social networking sites, and automated distribution agents (bots). Trojan programs can spread in a number of disguises; thus, identifying their malicious payload has become much more difficult.

Some experts consider viruses to be just a type of Trojan horse program, and this view has some validity. A virus is an unknown quantity that hides and spreads along with a legitimate program. In addition, any program can be turned into a Trojan by infecting it with a virus. However, the term *virus* specifically refers to the infectious code, rather than the infected host. The term *Trojan* refers to a deliberately misleading or modified program that does not reproduce itself.

Evidence of Trojans

Trojans leave many telltale signs. Any of the following may indicate an infected computer:

- Unrecognized new processes running
- Startup messages indicating that new software has been (or is being) installed (Registry updating)
- Unresponsiveness of applications to normal commands
- Unusual redirection of normal web requests to unknown sites
- Unexpected remote logon prompts at unusual times or unfamiliar logon prompt panels (this may result from routine software upgrades or session resets but can also indicate Trojan keylogging or password-capturing software)
- Sudden or unexpected termination of antivirus scanning software or personal firewall software (either at startup or when user attempts to load)

Logic Bombs

A **logic bomb** is a program that executes a malicious function of some kind when it detects certain conditions. Once in place, the logic bomb waits for a specified condition or time, which, when it occurs, causes the logic bomb to activate and carry out its tasks. The malicious tasks can cause immediate damage or can initiate a sequence of events that cause damage over a longer period.

Many logic bombs originate with organization insiders because they generally have more detailed knowledge of the IT infrastructure than outsiders do, so they can place logic bombs more easily. In addition, internal personnel generally know more about an organization's weak points and can identify more effective ways to cause damage. For example, a programmer might hide a program within other software that lies dormant, and should the company terminate his or her employment, he or she might activate the

program, which would cause the logic bomb to carry out malicious activities, such as deleting valuable files or causing other harm.

Logic bombs can be very difficult to identify because the designer creates them to avoid detection. In addition, the designer generally possesses knowledge of the organization's capabilities and security controls and can place logic bombs where they are less likely to attract attention.

Active Content Vulnerabilities

The term **active content** refers to components, primarily on websites, that provide functionality to interact with users. These components include any dynamic objects that do something when the user opens the webpage. Developers can use many technologies to create active content, including ActiveX, Cascading Style Sheets (CSS), React, Java, JavaScript, VBScript, macros, browser plug-ins, PDF files, media files, and other scripting languages. This code runs in the context of the user's browser and uses the user's logon credentials and is considered mobile code because these programs run on a wide variety of computer platforms.

Many Internet websites now rely on active content to create their look and feel. For these schemes to operate properly, the user must download these bits of mobile code, which can gain access to the hard disk. Once they activate, they can potentially do malicious things, such as fill up a desktop with infected file icons, which will spawn additional copies of the malicious code.

Malicious Add-Ons

As web browsers become ever more powerful, the number of programs that work with them, called **browser add-ons**, increases. Browser add-ons can add to a web browser's functionality in many ways, for example, by integrating news and weather alerts into the browser, but, unfortunately, because not all add-ons are trustworthy, they can also decrease security. Malicious add-ons are browser add-ons that contain some type of malware, and, once installed, they can perform many malicious actions. The best way to protect a device from malicious add-ons is to install only browser add-ons from trusted sources as well as periodically checking the add-ons that are

installed to ensure that you know which ones you are using. If you find any add-ons that you do not recognize, remove them.

TIP

For more information on removing malicious add-ons from any browser, take a look at *https://malwaretips.com/blogs/browser-toolbar-removal/*. This article specifically covers removing toolbars, but the website contains many other helpful articles about battling malware.

Injection

Malicious software uses many techniques to carry out attacks, such as the previously discussed overflow techniques, and **injection techniques**, which are also very popular in malware development. An injection action is when malicious software provides deliberately invalid input to some other software, the purpose of which is to cause an error condition and, hopefully, some state that allows an attack to occur. Injection weaknesses are always caused by software that does not properly validate input data. The most popular types of injection techniques include:

- **Cross-site scripting (XSS)**—This technique allows attackers to embed client-side scripts into webpages that users view so that, when a user views a webpage with a script, the web browser runs the attacking script. These scripts can be used to bypass access controls, and their effects can pose substantial security risks, depending on how sensitive the data is on the vulnerable site.
- **SQL injection**—A code injection is used to attack applications that depend on data stored in databases whereby SQL statements are inserted into an input field and executed by the application. SQL injection attacks allow attackers to disclose and modify data, violate data integrity, or even destroy data and manipulate the database server.

- **Lightweight Directory Access Protocol (LDAP) injection**—The LDAP injection exploits websites that construct LDAP based on user input. Web applications that do not sanitize input enable attackers to alter the way that LDAP statements are constructed. When an attacker modifies LDAP statements, they run with the same permissions as the component that executed the command.
- **Extensible Markup Language (XML) injection**—XML injection is a technique used to manipulate the logic of an XML application or service. Injecting XML content into an XML message can alter the logic of an application or even insert malicious content into an XML document.
- **Command injection**—The goal of this type of attack is to execute commands on a host operating system with a vulnerable application, which provides the ability for this attack to succeed. These attacks are possible only when an application accepts unvalidated user input and passes the input to a system shell.

The primary goal of any injection attack is to allow the attacker to perform unauthorized actions, which could be to access or modify data or even to execute code that should not be executed without authorization. The ability to successfully attack a computer or device and run unauthorized code is called an *arbitrary code execution* attack or a *remote code execution* attack.

Botnets

Hacking groups create **botnets** (short for *robotically controlled networks*) to launch attacks whereby they infect vulnerable machines with agents that perform various functions at the command of the controller, or bot-herder (i.e., a hacker who operates a botnet and controls the command and control server that sends commands to the agents). Typically, controllers communicate with other members of the botnet using Internet Relay Chat (i.e., a protocol that enables text conversations over the Internet) channels. Attackers have established thousands of botnets, which they use to distribute malware and spam and to launch DoS attacks against organizations or even countries. One of the largest botnets is the Mozi botnet, which first appeared in 2019. This botnet is similar to the smaller Mirai botnet, but, unlike Mirai,

which primarily targets online consumer devices such as Internet Protocol (IP) cameras and home routers, Mozi focuses on IoT devices, which accounted for nearly 90 percent of IoT traffic in the first half of 2020. The risk of botnets highlights the need to secure every computing device because attackers can use all types to launch attacks.

Denial of Service Attacks

The purpose of a **denial of service (DoS) attack** is to overwhelm a server or network segment to the point that it becomes unusable. A successful DoS attack crashes a server or network device or creates so much network congestion that authorized users cannot access network resources.

Standard DoS attacks use a single computer to launch the attack, whereas distributed denial of service (DDoS) attacks use intermediary hosts, which are compromised systems that contain Trojan-handler programs. These Trojan programs then act as agents to execute a coordinated attack on a target system or network in which the attacker controls one or more master handler servers, each of which can control many agents or daemons. The agents receive instructions to coordinate a packet-based attack against one or more victim systems.

FYI

Botnets are the main source of distributed denial of service (DDoS) attacks and spam. They are programs that hide on compromised computers and wait for a command to "wake up" and carry out certain instructions. Botnets are extremely resistant to takedown and can be hard to detect because they exist on many different computers. Botnet DoS attacks are growing and spreading so rapidly that authors trying to describe them cannot keep up.

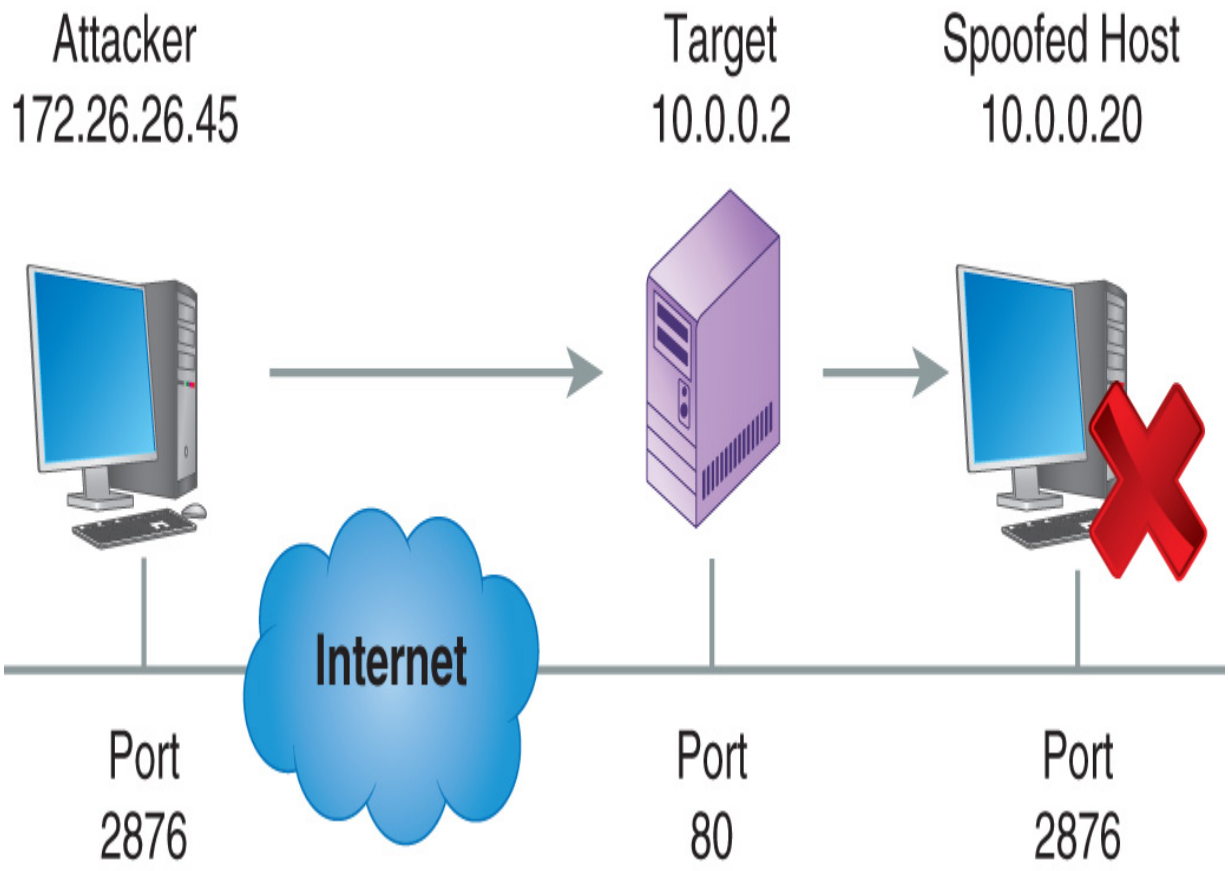
In October 2019, a group of activists with hacking abilities, called hacktivists, launched a series of DDoS attacks, website defacements, and XSS attacks against a number of Chilean government institution websites, all

of which were intended to support protests in Chile against the government. The operation is called OpChile, and it continues today with ongoing attacks and protests. Hacktivists are behind more and more large-scale attacks, the general intent of which is to attract attention to a political or social issue.

Three parties are involved in these attacks: the attacker, the intermediaries (i.e., handlers and agents), and the victim(s). Even though the intermediary is not the intended victim, it too can suffer the same types of problems that the victim does in these attacks. You can find additional information on DDoS attacks on the Computer Emergency Response Team (CERT) website at *www.sei.cmu.edu/about/divisions/cert/index.cfm*. As an example of how prevalent DDoS attacks are becoming, the largest DDoS attack on record occurred in February 2020. Amazon reported that its AWS Shield service mitigated a 2.3 Tbps DDoS attack for an undisclosed customer. To read about this unprecedented attack, see *www.zdnet.com/article/aws-said-it-mitigated-a-2-3-tbps-ddos-attack-the-largest-ever/*.

SYN Flood Attacks

One popular technique for DoS attacks is called a *SYN flood*. In a SYN (short for synchronize) flood, the attacker uses IP spoofing to send a large number of packets requesting connections to the victim computer. These requests appear to be legitimate but in fact reference a client system that is unable to respond to a specific network message during the connection establishment process. The victim computer records each connection request; reserves a place for the connection in a local table in memory; and then sends an acknowledgment, called a SYN-ACK message, back to the attacker. Normally, the client would finish establishing the connection by responding to the SYN-ACK message with an ACK message. However, because the attacker used IP spoofing, the SYN-ACK message goes to the spoofed system, which results in the client never sending the ACK message. The victim computer then fills up its connections table waiting for ACK messages for all the requests, while, in the meantime, no legitimate users can connect to the victim computer because the SYN flood has filled the connection table. The victim computer will remain unavailable until the connection requests time out, and, even then, the attacking system can simply continue requesting new connections faster than the victim system can terminate the expired pending connections. **FIGURE 8-11** shows how a SYN flood attack works.



SYN, SRC: 10.0.0.20, DST: 10.0.0.2	SYN-ACK	?
SYN, SRC: 10.0.0.20, DST: 10.0.0.2	SYN-ACK	?
SYN, SRC: 10.0.0.20, DST: 10.0.0.2	SYN-ACK	?
SYN, SRC: 10.0.0.20, DST: 10.0.0.2	SYN-ACK	?
SYN, SRC: 10.0.0.20, DST: 10.0.0.2	SYN-ACK	?

FIGURE 8-11 How a SYN flood attack works.

Smurf Attacks

In a smurf attack, attackers direct forged Internet Control Message Protocol (ICMP) echo request packets to IP broadcast addresses from remote locations to generate DoS attacks. Three parties are involved in these attacks: the attacker, the intermediary, and the victim. (Note that the intermediary can also be a victim.) The intermediary receives an ICMP echo request packet directed to the IP broadcast address of its network. If the intermediary does not filter ICMP traffic directed to IP broadcast addresses, many of the machines on the network will receive this ICMP echo request packet and send back an ICMP echo reply packet. When (potentially) all the machines on a network respond to this ICMP echo request, the result can be severe network congestion or outages. **FIGURE 8-12** shows how a smurf attack works.

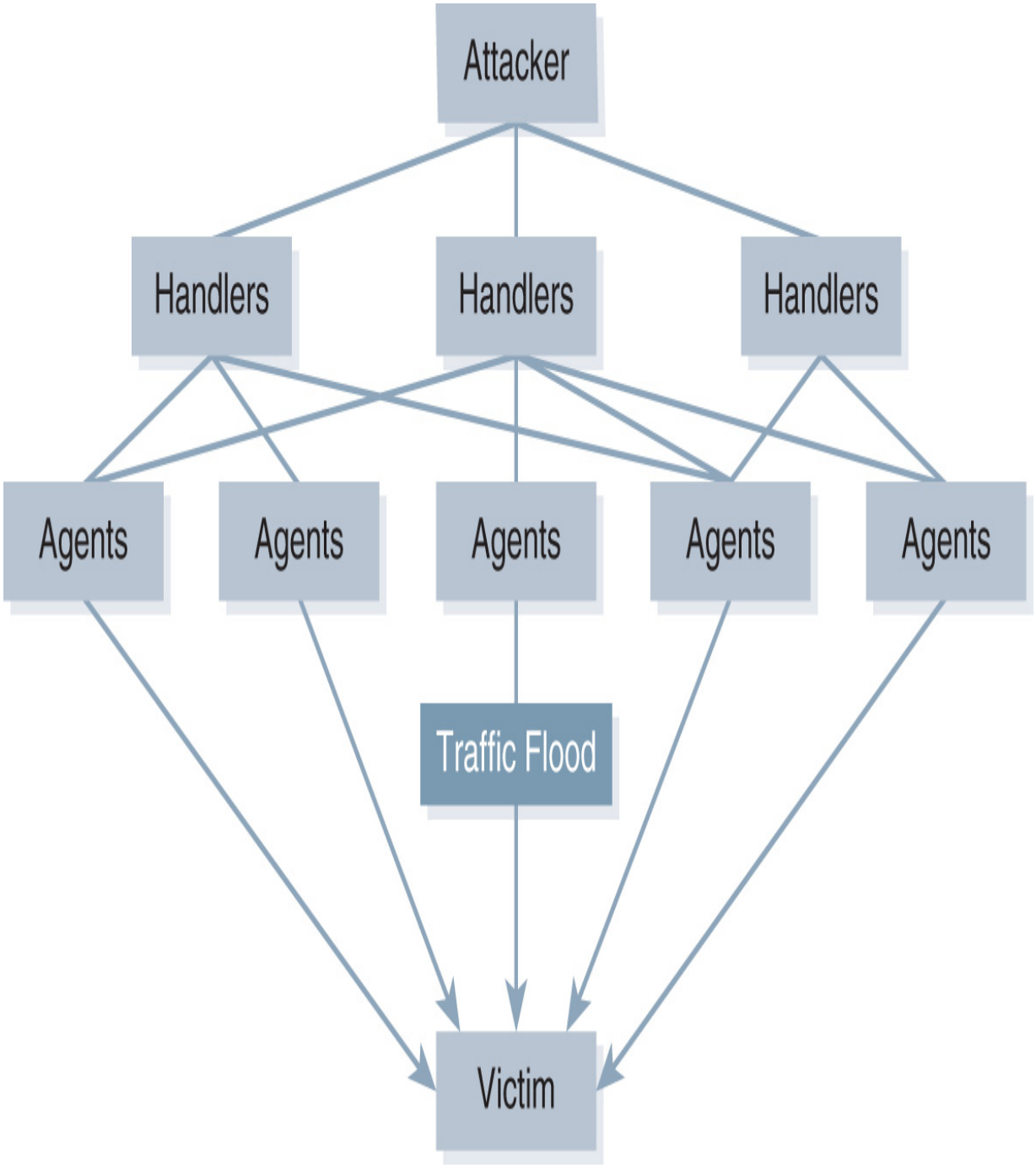


FIGURE 8-12 How a smurf attack works.

Spyware

Spyware is any unsolicited background process that installs itself on a user's computer and collects information about the user's browsing habits and

website activities. These programs usually affect privacy and confidentiality and are typically installed when users download freeware programs.

A **cookie** is a small text file that stores information about a browser session. The server side of a user connection to a web server can place certain information in the cookie and then transfer that cookie to the user's browser. Later, the same server can ask the browser for the cookie and retrieve the information the browser previously stored. This information becomes useful in any intelligent interaction between browser and website because the browser does not maintain a connection with the server between requests.

Spyware cookies are cookies that share information across sites and can reveal and share private information collected among multiple sites. Some cookies are persistent and stored on a hard drive indefinitely without the owner's permission. Spyware cookies include those containing text, such as *247media*, *admonitor*, *adforce*, *doubleclick*, *engage*, *flycast*, *sexhound*, *sextracker*, *sexlist*, and *valueclick* in their names. Adobe Flash uses Locally Shared Objects (LSOs), often called *Flash cookies*, in the same way that websites use cookies, to store small amounts of data for websites that use Flash applications. These LSOs can be used by attackers to store and disclose sensitive user data. In recent years, Flash was used in many attacks due to its numerous vulnerabilities; therefore, partially due to its use in so many attacks, Adobe Flash was discontinued at the end of 2020.

NOTE

Cookies and email attachments are the two most common techniques attackers use to spread malware. Unsuspecting users who accept cookies or open attachments provide the easiest way for attackers to place malware on computers or mobile devices.

Adware

Adware programs trigger such nuisances as popup ads and banners on certain websites. They affect productivity and may combine with active background activities, such as homepage hijacking code. In addition, adware collects and tracks information about application, website, and Internet activity.

The problem with spyware and adware lies in distinguishing between legitimate and illicit activities. Spyware and adware companies have taken full advantage of this nebulousness, often suing anti-spyware companies for labeling their programs as spyware.

Phishing

A *phishing* attack tricks users into providing logon information on what appears to be a legitimate website but is in fact one set up by an attacker to obtain this information. To make such sites appear legitimate, attackers use very sophisticated technologies. If they can obtain logon information for financial institutions, for example, they may be able to steal from the victim.

Spear Phishing

To increase the success rate of a phishing attack, some attackers supply information about the victim that appears to come from the legitimate company. They obtain this information in many ways, including guessing, sifting through trash ("dumpster diving"), or sending bogus surveys.

Pharming

The term *pharming* originates from the term *phishing*, which refers to the use of social engineering to obtain access credentials, such as usernames and passwords. Pharming is possible through the exploitation of a vulnerability in Domain Name System (DNS) server software. These servers are the machines responsible for resolving Internet domain names into their real IP addresses. The vulnerability that exists in DNS server software enables an attacker to acquire the domain name for a site and, for example, redirect that website's traffic to another website. If the website receiving the traffic is a fake website, such as a copy of a bank's website, it can be used to phish, or steal, a computer user's password, PIN, or account number. For example, in January 2005 one of the first known instances of pharming occurred in which

an attacker hijacked the domain name for a large New York Internet service provider (ISP), Panix, to a site in Australia. Other well-known companies also became victims of this attack. (Note that this is possible only when the original site is not SSL [Secure Sockets Layer] protected or the user ignores warnings about invalid server certificates.)

Keystroke Loggers

Keystroke loggers are insidious and dangerous tools in the hands of an attacker. Whether software- or hardware-based, a keystroke logger captures keystrokes, or user entries, and then forwards that information to the attacker, which then enables the attacker to capture logon information, banking information, and other sensitive data. Hardware-based keystroke loggers are easy to detect because they must be plugged in somewhere between the keyboard and the computer, whereas a software keystroke logger is very difficult to detect because it has no physical presence.

To combat keystroke loggers, some people have turned to onscreen virtual keyboards, to which black-hat hackers have responded by distributing malware that takes snapshots of the screen around the area clicked by the mouse. On and on, the battle between security and hackers wages as each side continues to develop new threats and new solutions.

Hoaxes and Myths

Although virus hoaxes are not always malicious, spreading unverified warnings and bogus patches can lead to new vulnerabilities. Often, the objective of the creator of the hoax or myth is merely to observe how widely the ruse can be propagated. This is a new version of the old chain-letter attack, in which an attacker sent a person a letter promising good luck or happiness if the person forwarded the message to a dozen people.

Following are guidelines for recognizing hoaxes, especially virus hoaxes:

- **Did a legitimate entity (e.g., computer security expert or vendor) send the alert?**—Inspect any validation certificates or at least the source uniform resource locator (URL) of the advisory.

- **Is there a request to forward the alert to others?**—No legitimate security alert will suggest that the recipient forward the advisory.
- **Are there detailed explanations or technical terminology in the alert?**—Hoaxes often use technobabble to intimidate the recipient into believing the alert is legitimate, whereas a legitimate advisory typically omits any details and simply refers the recipient to a legitimate website for that information. Moreover, the website also typically provides a suggestion for protection activities.
- **Does the alert follow the generic format of a chain letter?**—In this format, there is a hook, a threat, and a request: The hook is a catchy or dramatic opening or subject line to catch the recipient's attention; the threat is a technical-sounding warning of serious vulnerabilities or damage; and the request is a plea to distribute the alert or a suggestion to take an immediate action, for example, to download a patch from a linked website.

Homepage Hijacking

The function of these attacks is to change a browser's homepage to point to the attacker's site. There are two forms of hijacking:

- **Exploiting a browser vulnerability to reset the homepage**—Many types of active content can change the browser's homepage, often without the user's permission. Even without resorting to covert means, convincing users to select an action that does more than they expect is easy. Just because a user clicks a button that says "Remove Infected Programs from My Computer" does not mean that is the action that will occur.
- **Covertly installing a browser helper object (BHO) Trojan program**—This Trojan contains the hijacking code. Once a BHO executes, it can change the browser's homepage back to the hijacker's desired site. Typically, hijacker programs put a reference to themselves into the operating system's startup procedures, which allows the hijacker to run every time the computer reboots. Trying to change any of these settings before finding and removing the hijacking software is futile because the hijacker will simply change them back.

Webpage Defacements

The term *web defacement* or *web graffiti* refers to someone gaining unauthorized access to a web server and altering the index page of a site on the server. Usually, the attacker exploits known vulnerabilities in the target server and gains administrative access. Once in control, the attacker replaces the original pages on the site with altered versions.

Typically, the defacement represents graffiti, which most security practitioners consider as merely a nuisance, but the potential for embedding malicious active content code, such as viruses or Trojans, into the website does exist. Code Red, for instance, included a payload that installed a backdoor Trojan, which allowed attackers remote access to an infected Microsoft Internet Information Services (IIS) server in order to deface the front page of the web server. You can minimize the risk of this type of attack by ensuring that you install current software versions and security patches.

How Can Attackers Attack Web Applications?

Applications that users access using a web browser are called *web applications*. Most people think of web applications as just websites, but they really are far more powerful. A web application generally provides access to data in a database and uses that data to provide a service to the user, for example, online shopping sites. Attackers often target web applications since the application provides access to vast amounts of data. One method attackers use is called *session hijacking*, which is an attack in which the attacker intercepts network messages between a web server and a web browser. It extracts one or more pieces of data, most commonly a session ID, and uses that to communicate with the web server. The attacker pretends to be an authorized user by taking over the authorized user's session. The technique used when the attacker masquerades as an authorized user is called *header manipulation*. The attacker creates a Hypertext Transfer Protocol (HTTP) message for the web server but changes (manipulates) the HTTP header to include the intercepted session ID. When the web server receives the altered HTTP message, it thinks the attacker is an authorized user. This is an effective attack for web applications that fail to authenticate each request.

FYI

Backdoor programs are typically more dangerous than computer viruses because intruders can use backdoor programs to take control of a computer and potentially gain network access. These programs are also commonly referred to as *Trojan horses* because they pretend to do something other than what they actually do. They typically arrive as attachments to emails with innocent-looking filenames.

A Brief History of Malicious Code Threats

In the early days of computing, malware spread from computer to computer via diskettes that were handed from person to person. This manual transmission method was called *sneakernet* because someone had to walk from one computer to another for those computers to communicate. With sneakernets, a virus could take months to spread across the globe. In contrast, today's viral infections spread via networks and can cross the globe in a matter of seconds. As the virus-writing community evolved, more and more sophisticated viruses began to emerge. Some could spread via email, mobile code, or macros, and others could spread in multiple ways.

1970s and Early 1980s: Academic Research and UNIX

The idea of self-replicating computer programs has been around for decades and has appeared in literature, scientific papers, and even experiments since the early 1970s. Researchers made early attempts to perform routine maintenance tasks on large networks using self-distributing code (worms), but the technology did not become widespread or well known.

A key event in hostile code development was the research performed by Dr. Fred Cohen in 1983 from which came his paper, "Computer Viruses—Theory and Experiments," published in 1984, that defined the computer virus and described experiments he and others performed to prove the viability of viral code. Cohen published this work before anyone had observed the first computer viruses.

The Internet during this period was a network that primarily connected university computers to one another and was vulnerable to programs that could propagate using existing communications protocols. A university student named Robert Morris—who unleashed the first major malware incident, the Morris Worm, in November 1988—demonstrated this idea. This UNIX-based worm overwhelmed almost all computers on the Internet, causing a great deal of media interest and many headlines.

1980s: Early PC Viruses

The first personal computers (PCs) hit the market in the early 1980s, and their popularity grew quickly. By the late 1980s, the PC was an indispensable and affordable business technology for many companies, and this rapid growth also brought computer technology closer to a larger number of individuals.

The PC operating system was disk-based (DOS), and most software and data files migrated between PCs via floppy diskettes. Two primary types of malicious virus code emerged to exploit this fact: boot sector viruses, which attacked the operating system components located on disks and in memory, and file-infecting viruses, which attacked the executable files themselves.

Brain (a boot sector virus), Lehigh, and Jerusalem (a file-infecting virus) are examples of the earliest viruses. They propagated primarily via floppy disks and downloads from popular computer bulletin board (BBS) archives. Another early virus, Elk Cloner, which targeted the Apple II computer, also spread by floppy disks.

1990s: Early LAN Viruses

Local area networks (LANs) began to appear in business environments by the early 1990s, a development that gave the traditional file viruses a fertile environment in which to propagate. Very few people understood the virus problem at this time, and finding a virus was a rare event. Interested users collected the samples they found and freely distributed those, giving rise to notorious virus exchange bulletin boards. Some viruses did cause damage, and business users started to become aware of the problem. The boot sector virus Form5 became the most widespread virus during this period. Another well-known and very destructive virus of this era was Dark Avenger, also known as Eddie6.

By the end of the decade, LANs had become a key infrastructure in most companies, while, at the same time, the use of the Internet for communications—particularly email and data file transfer—became widespread. Traditional boot sector and file-infecting viruses began to diminish in frequency as storage technology advanced with the introduction of CD-ROMs.

Mid-1990s: Smart Applications and the Internet

The popularity of email, combined with the ease of attaching files, gave rise to the extremely widespread distribution of malicious code using the same techniques demonstrated years earlier by Morris: email worms. These programs locate email address files within a user's system and then generate multiple copies of themselves, often disguised as innocent-looking file attachments. The well-known email worms named Melissa and Loveletter are examples. Although many of these earlier programs relied on users to activate the code by opening attachments, newer forms of worms have exploited various security weaknesses in the increasing numbers of always-on computers and servers. For example, Code Red exploited vulnerabilities in Microsoft web servers (IIS) and had exceptional replication speed.

The Internet provides an environment from which individuals and groups can extend their activities beyond functional and geographic boundaries. During the mid-1990s, hacking (or cracking) became a growing business security concern. Using automated tools and more structured approaches, these individuals and groups have continued to evolve. The inherent resiliency of Internet communications protocols became a way to disrupt normal operations and gave rise to DoS attacks against popular websites.

New forms of malicious code evolved in the 1990s, including Trojan programs, such as Back Orifice and AIDS. More resilient and stealthy variants of virus code also evolved, including polymorphic versions, such as Tequila. In addition, new programming languages designed for portability and functionality presented new opportunities to develop additional forms of malicious code. StrangeBrew was the first virus to infect Java files. Though harmless, the virus modified CLASS files to contain a copy of itself.

With the introduction of advanced programming features into popular application software, the rise of other forms of malicious code appeared to infect document files. The first macro virus, WM/Concept7, was discovered in August 1995 and spread through the transmission of a simple document file.

2000 to the Present

As personal and corporate Internet connectivity continued to increase in the new century, authors of popular browser technologies added numerous companion tools or plug-ins. These tools use specialized scripting codes that can automate common functions and comprise a generation of active content code that exposes additional opportunities to attackers.

The number of computers and devices now connected to the Internet, especially popular server platforms running Windows and other widely distributed software, has created new vulnerabilities. The replication speed of Internet worms coupled with today's high-speed computers, as well as increasing interactive probing for vulnerabilities by hostile groups, mandates continuous improvement, monitoring, and testing of IT security by organizations and user communities.

The W32/Nimda worm, taking advantage of backdoors left behind by the Code Red II worm, was the first to propagate itself via several methods, including email, network shares, and an infected website. The worm spreads from client to web server by scanning for backdoors. The Klezworm infects executables by creating a hidden copy of the original host file and then overwriting the original file with itself.

The latest communications revolution started with the introduction of the iPhone in 2007 and the Android smartphones in 2008. The availability of these products started a shift in consumer perception of mobile communication. Over time, mobile devices have become more powerful and prevalent so that, today, more people use mobile devices than use PCs. Moreover, these devices have become plentiful and nearly essential to everyday life. Attackers know how much users rely on information mobile devices store and process as well as that the majority of users neglect to secure these devices. Because of the increasing number of vulnerable targets, many new malware attacks target mobile devices instead of traditional computers, and, as more and more appliances and other types of devices are Internet connected, the problem with malware is only growing worse. As watches, refrigerators, cars, and thousands of other types of devices connect to the Internet, attackers see many more opportunities to attack.

Threats to Business Organizations

Security threats from malware originate from a variety of sources, ranging from isolated incidents involving a single, unsophisticated perpetrator to complex, structured attacks against multiple targets by organized groups. These threats generally originate outside an organization's IT infrastructure and user community. For this reason, organizations make a significant effort to detect, respond, mitigate, and recover from these attacks.

Less publicized yet equally troublesome are threats that originate from within an organization, which are due to improper or deficient security policies and unsafe user practices. It is the IT security practitioner's responsibility to understand the nature and significance of any such internal threat and to implement effective countermeasures and practices.

Regardless of an attack's origin, malware poses a serious threat to today's organizations. To conduct business, every organization must be able to carry out critical business functions, which may be directly or indirectly related to IT assets, depending on the organization's main line of business. For example, Amazon.com is extremely dependent on its web servers and Internet connections, whereas a local fruit and vegetable stand is probably less so. However, even a small fruit and vegetable stand may depend on a smartphone or tablet to process payment cards. In either case, big or small, the organization must understand what IT assets and services it needs to conduct business and take steps to protect them from attack. Planning that focuses on protecting critical business functions helps to avoid wasted effort and money while increasing the likelihood of staying in business.

Types of Threats

Malware can threaten businesses in the following ways:

- **Attacks against confidentiality and privacy**—These attacks include emerging concerns with respect to identity theft and trade secrets at both the individual and corporate levels.

- **Attacks against data integrity**—Economic damage or loss due to the theft, destruction, or unauthorized manipulation of sensitive data can be devastating to an organization. Organizations depend on the accuracy and integrity of information. The legitimacy of the source of communications also affects the integrity of the transmitted data.
- **Attacks against availability of services and resources**—Businesses increasingly depend on the Internet as a means of conducting primary business functions. As a result, hostile attacks that obstruct critical business functions and providing services to legitimate users have become an increasing concern among IT security practitioners. Aggressive prevention, early detection, and quick recovery are essential to maintaining an acceptable level of service.
- **Attacks against productivity and performance**—Mass bulk email (spam), spyware, persistent cookies, and the like consume computing resources and reduce user productivity, as does unnecessary reaction to nonexistent code threats, such as hoaxes. Moreover, ransomware can reduce performance to zero by making important data inaccessible until the ransom is paid. For these reasons, security professionals must make regular efforts to minimize the impact of such threats.
- **Attacks that create legal liability**—Unaddressed vulnerabilities can extend beyond the legal boundaries of an organization, creating a potential liability to customers, trading partners, and others. Liabilities can include fines and other financial and performance requirements imposed by courts, business partners, or regulatory agencies.
- **Attacks that damage reputation**—Malware attacks can leak sensitive information about a company or its customers or otherwise embarrass a company. Even in the absence of mass sensitive data leaks, other attacks that are publicized can expose an organization's weaknesses. Such attacks can damage an organization's reputation, which can result in a loss of customers and potential revenue.

Internal Threats from Employees

Although attackers initiate more notorious security threats from outside a target network, a number of significant vulnerabilities also exist inside a trusted network. External attackers must spend time learning about the

strengths and weaknesses of intended victims, whereas internal personnel often have access to information that can make attacks easier to carry out and often harder to detect and stop. These types of attacks demand the IT security practitioner's attention.

Many of these vulnerabilities exist because of unsafe computing practices by personnel. These practices include the following:

- The exchange of untrusted media among systems
- The installation of unauthorized, unregistered software (application and OS)
- The unmonitored download of files from the Internet
- The uncontrolled dissemination of email, social media, or other messaging application attachments

Security breaches can also originate from within the targeted organization, perpetrated by current and former employees. These breaches often go undetected due to weak personnel and security policies or ineffective countermeasures and frequently go unreported by the organization that was attacked. These breaches can include the following:

- Unauthorized access to system and network resources
- Privilege escalation
- Theft, destruction, or unauthorized dissemination of data
- Use of corporate network resources to initiate hostile attacks against outside targets
- The accidental or intentional release of malicious code into internal network segments not protected by perimeter controls and intrusion detection countermeasures

Anatomy of an Attack

Understanding the objective of malicious code attacks, as well as what the attackers are targeting, is important to understanding threats and developing practical and effective countermeasures. In this section, you will learn how to identify key targets of malware attacks and describe the key characteristics and hostile objectives of each type of attack. This section covers the following:

- What motivates attackers
- The purpose(s) of an attack
- Types of attacks
- Phases of an attack

What Motivates Attackers?

Contrary to popular belief, today's attackers are not simply social outcasts just wanting a thrill and writing malware from their parents' basement. They are far more sophisticated and carry out attacks for one or more primary reasons:

- They want money.
- They want to be famous.
- They want to impose their political beliefs or systems on others.
- They are angry, and they want to exact revenge on those who have angered them.
- They work for a nation-state and are carrying out state-level cyberwarfare or economic espionage.

The Purpose of an Attack

There are four main purposes of an attack:

- **Denial of availability**—The goal of some attacks, such as a DoS, DDoS, or ransomware attack, is to prevent legitimate users from accessing a system or data.
- **Data modification**—The attacker might issue commands to access a file on a local or network drive and modify, delete, or overwrite it with new data. Alternatively, the attacker might modify system settings or browser security settings.
- **Data export (exfiltration)**—Attackers might seek to steal information from a computer and forward it over the Internet or via email to an attacker. For instance, many Trojan horses forward usernames and passwords to an anonymous attacker's email address on the web, which the attacker can then use to access protected resources.
- **Launch point**—An attacker might target a computer for use as a launch point to infect and target other computers as part of a larger attack plan.

Types of Attacks

There are four primary types of attack:

- Unstructured attacks
- Structured attacks
- Direct attacks
- Indirect attacks

Unstructured Attacks

Moderately skilled attackers generally perpetrate unstructured attacks against network resources. Often, the initial intent of the attacker is simply personal gratification—the thrill of the challenge and claim of prestige—of gaining illegal access. Any level of success can lead to yet more malicious activity, such as defacement or the inadvertent crashing of systems. Occasionally, an unstructured attack exposes an unintended vulnerability; the attacker may then switch to a more methodical approach. All such activity is of concern to IT security practitioners because it represents a compromise of defensive measures.

Structured Attacks

Highly motivated and technically skilled attackers, acting alone or in groups, use complex tools and focused efforts to conduct structured attacks. They understand, develop, and use sophisticated hacking techniques to identify, probe, penetrate, and carry out malicious activities, motivated by money, anger, destruction, or political objectives.

Regardless of their motivation, these attackers can and do inflict serious damage to networks. They usually conduct structured attacks in phases after an overall goal is established, such as targeting a specific organization or a specific technology (e.g., an operating system).

Direct Attacks

Attackers often conduct direct attacks against specific targets, such as certain organizations, as well as conducting direct attacks against target classes, that is, networks using certain hardware, operating system versions, or services. An example is an IIS Unicode attack against specific web servers in an organization.

These exploits might be unstructured, for example, when a script kiddie uses well-known hacker tools to uncover vulnerable sites and then conducts random exploits around the compromised network through trial and error. These exploits might also be structured attacks by individual crackers or by coordinated cyberterrorist groups, and they could advance methodically through phases to achieve their desired goals.

Typically, an attacker conducts a real-time direct attack by accessing a target system through remote logon exploits, for example, password guessing or session hijacking. Alternatively, the attacker might exploit a known vulnerability in the target operating system, such as a Unicode vulnerability or an active content vulnerability. **FIGURE 8-13** shows a direct attack.

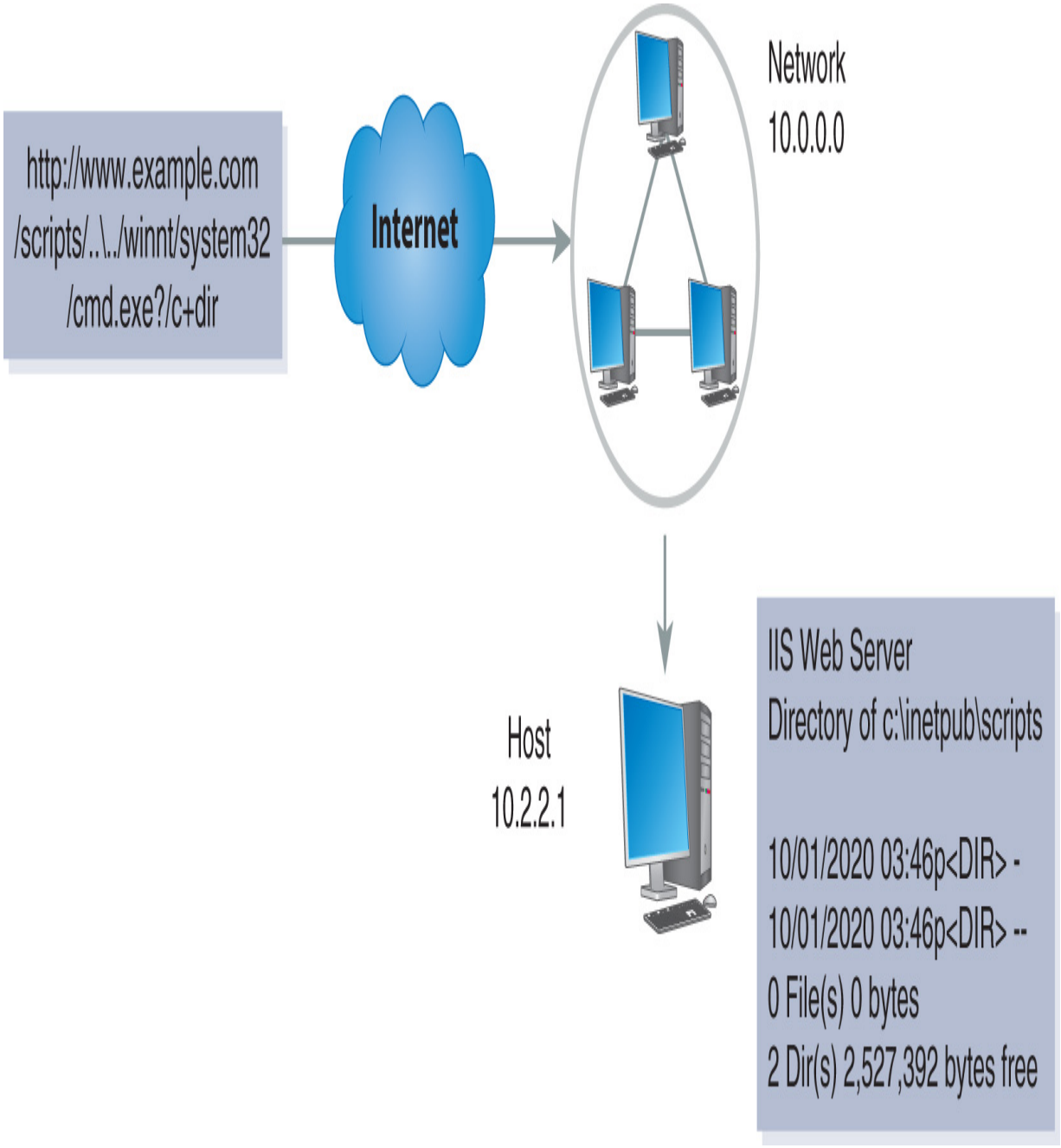


FIGURE 8-13 How a direct attack works.

The key characteristic of direct attacks is that they occur in real time. Depending on the sophistication of the attacker, the final objective may simply be to deface a website. Alternatively, it might be a prelude to more malicious structured attacks. For example, the attacker might seek to locate and compromise a weakly protected target system and then implant Trojan

programs on it to exploit other resources (files or systems) within the compromised network.

Indirect Attacks

Indirect attacks occur as a natural result of preprogrammed hostile code exploits, such as Internet worms or viruses. These attacks are unleashed indiscriminately and often propagate rapidly and widely. Although the worm or virus might exploit a specific system or application vulnerability, its replication and transmission occur indiscriminately.

Most likely, the goal of a direct attack against a specific target might be to establish a starting point for an indirect attack against a more widely dispersed population. For example, the intended goal might be to compromise a single web server to install an email worm as a DoS exploit.

Phases of an Attack

To develop an attack plan with a reasonable chance of success, attackers need to know as much as possible about the target(s) of their attack. To this end, they develop a strategy. Clever attackers are also concerned about not leaving tracks that allow investigators to identify them. This section details the phases of an attack, which are shown in **FIGURE 8-14**.

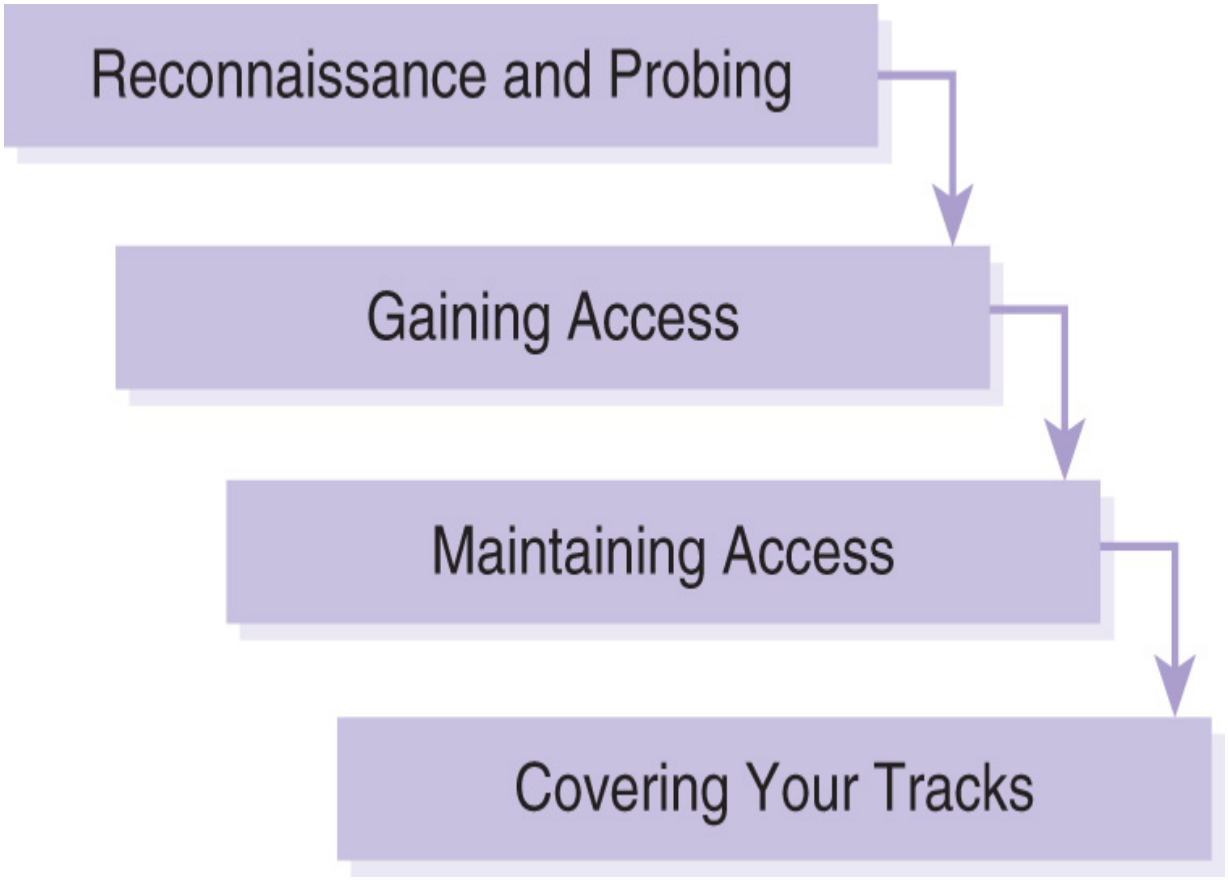


FIGURE 8-14 Phases of an attack.

Reconnaissance and Probing

When the overall goal or objective of an attack is clear, the attacker must probe the target network to identify points of possible entry, that is, the vulnerabilities. The reconnaissance and probing phase of an attack is arguably the most important phase because it is the one in which an attacker collects all the information necessary to conduct a successful attack. In fact, using the information gathered in this phase is the easy part of an attack. This phase generally involves the use of common tools that are readily available on the Internet. These tools are generally part of the underlying protocol suite or are custom developed to exploit specific or potential targets.

These tools can include the following:

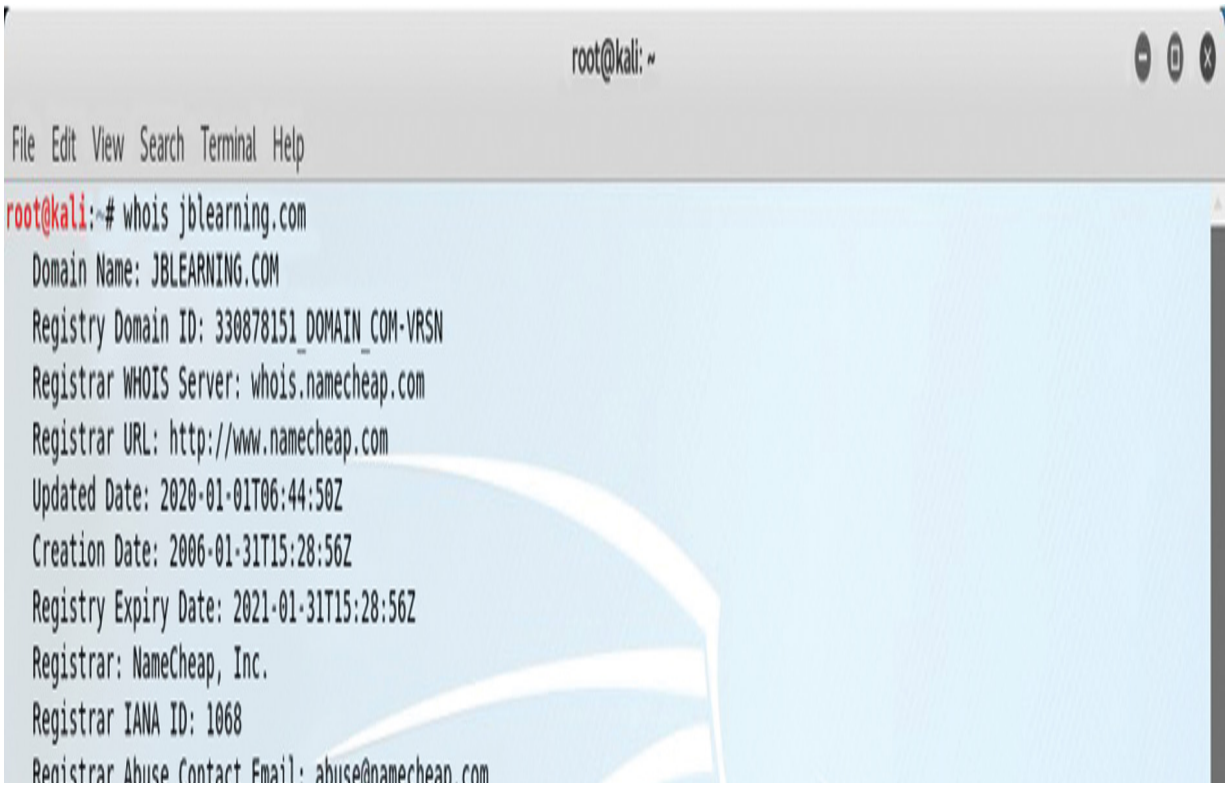
- DNS and ICMP tools within the Transmission Control Protocol/Internet Protocol (TCP/IP) protocol suite
- Standard and customized SNMP tools

- Port scanners and port mappers
- Security probes

Attackers might use these tools independently or, alternatively, as a coordinated suite to gain a complete understanding of a targeted network, which includes the protocols and operating system used, the server platforms employed, the services and ports that are open, the actual or probable network addressing and naming used, and so on.

The Internet and other public sources can provide additional information to profile targets. Such information includes the location of facilities, key personnel, and likely business partners. This last piece of information might seem trivial, but an indirect assault committed through a trading partner with serious security breaches is very possible.

DNS, ICMP, and Related Tools. DNSs act like phone books, matching a website's domain name with its IP address. A number of searchable websites enable anyone to find information about registered addresses. In addition, TCP/IP supports discovery tools, such as Whois and finger, which can be used to gather preliminary information in profiling a target site. **FIGURE 8-15** shows the output from a Whois lookup.



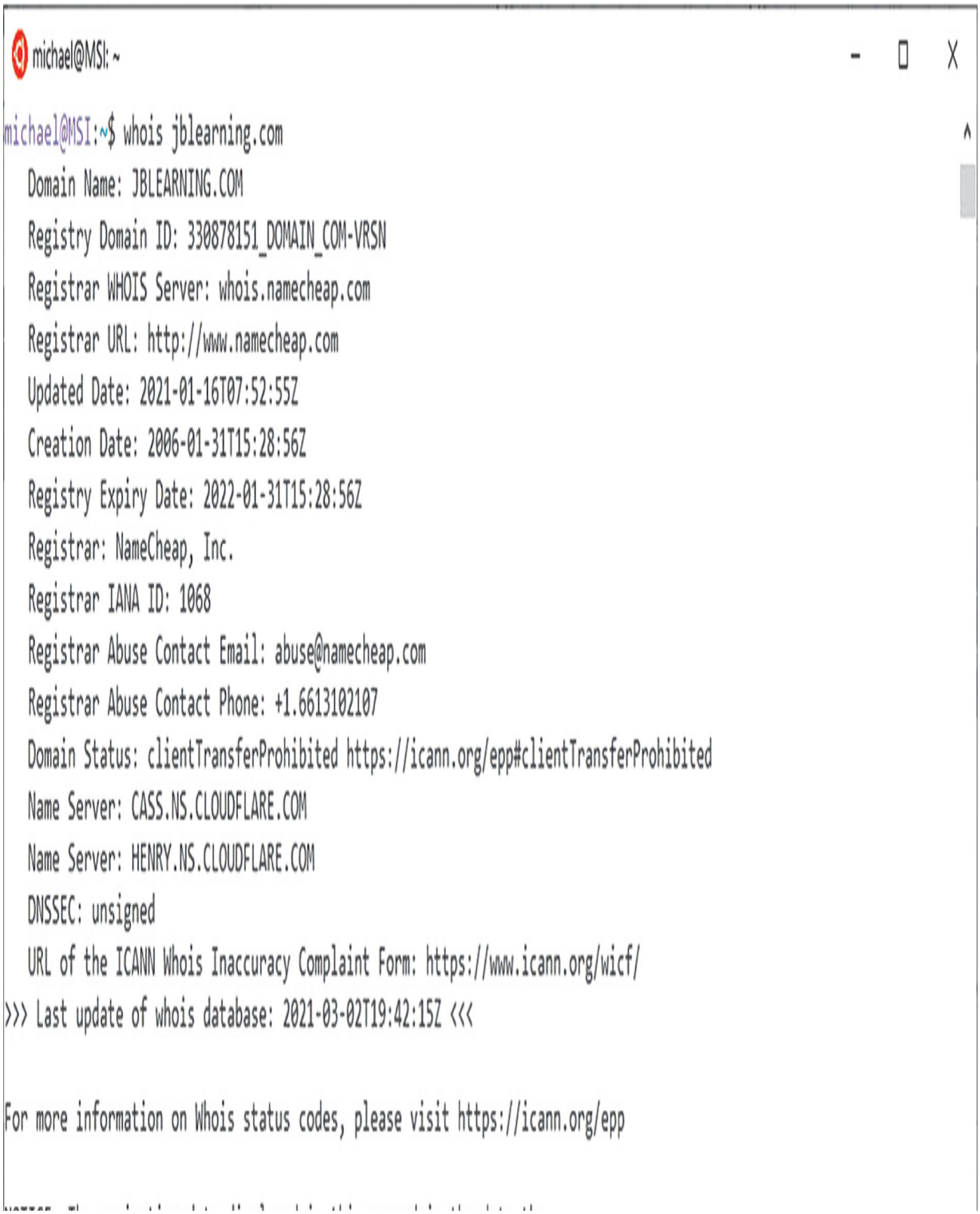
Registrar Abuse Contact Email: abuse@namecheap.com
Registrar Abuse Contact Phone: +1.6613102107
Domain Status: clientTransferProhibited https://icann.org/epp#clientTransferProhibited
Name Server: CASS.NS.CLOUDFLARE.COM
Name Server: HENRY.NS.CLOUDFLARE.COM
DNSSEC: unsigned
URL of the ICANN Whois Inaccuracy Complaint Form: https://www.icann.org/wicf/
>>> Last update of whois database: 2020-12-17T00:29:57Z <<<

For more information on Whois status codes, please visit https://icann.org/epp

NOTICE: The expiration date displayed in this record is the date the
registrar's sponsorship of the domain name registration in the registry is
currently set to expire. This date does not necessarily reflect the expiration
date of the domain name registrant's agreement with the sponsoring
registrar. Users may consult the sponsoring registrar's Whois database to
view the registrar's reported date of expiration for this registration.

TERMS OF USE: You are not authorized to access or query our Whois
database through the use of electronic processes that are high-volume and
automated except as reasonably necessary to register domain names or
modify existing registrations; the Data in VeriSign Global Registry
Services' ("VeriSign") Whois database is provided by VeriSign for
information purposes only, and to assist persons in obtaining information
about or related to a domain name registration record. VeriSign does not
guarantee its accuracy. By submitting a Whois query, you agree to abide
by the following terms of use: You agree that you may use this Data only
for lawful purposes and that under no circumstances will you use this Data
to: (1) allow, enable, or otherwise support the transmission of mass
unsolicited, commercial advertising or solicitations via e-mail, telephone,
or facsimile; or (2) enable high volume, automated, electronic processes
that apply to VeriSign (or its computer systems). The compilation

that apply to Verisign (or its computer systems). The compilation,
repackaging, dissemination or other use of this Data is expressly


michael@MSI: ~
michael@MSI:~$ whois jblearning.com
Domain Name: JBLEARNING.COM
Registry Domain ID: 330878151_DOMAIN_COM-VRSN
Registrar WHOIS Server: whois.namecheap.com
Registrar URL: http://www.namecheap.com
Updated Date: 2021-01-16T07:52:55Z
Creation Date: 2006-01-31T15:28:56Z
Registry Expiry Date: 2022-01-31T15:28:56Z
Registrar: NameCheap, Inc.
Registrar IANA ID: 1068
Registrar Abuse Contact Email: abuse@namecheap.com
Registrar Abuse Contact Phone: +1.6613102107
Domain Status: clientTransferProhibited https://icann.org/epp#clientTransferProhibited
Name Server: CASS.NS.CLOUDFLARE.COM
Name Server: HENRY.NS.CLOUDFLARE.COM
DNSSEC: unsigned
URL of the ICANN Whois Inaccuracy Complaint Form: https://www.icann.org/wicf/
>>> Last update of whois database: 2021-03-02T19:42:15Z <<<
For more information on Whois status codes, please visit https://icann.org/epp

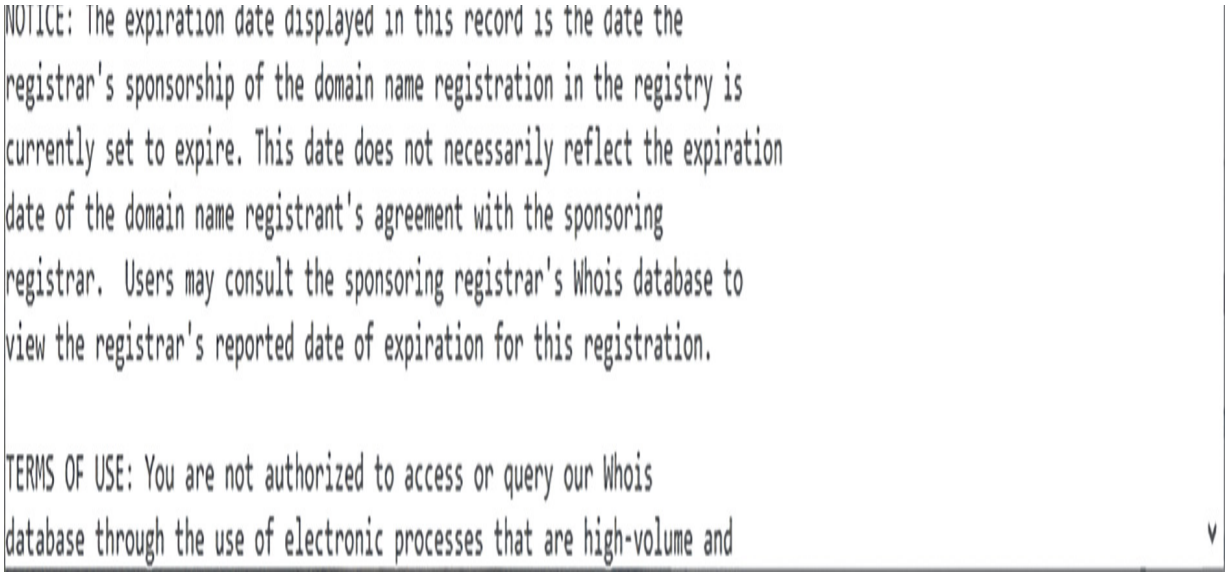

NOTICE: The expiration date displayed in this record is the date the
registrar's sponsorship of the domain name registration in the registry is
currently set to expire. This date does not necessarily reflect the expiration
date of the domain name registrant's agreement with the sponsoring
registrar. Users may consult the sponsoring registrar's Whois database to
view the registrar's reported date of expiration for this registration.
TERMS OF USE: You are not authorized to access or query our Whois
database through the use of electronic processes that are high-volume and

FIGURE 8-15 Results from a Whois lookup.

Reverse DNS lookup and nslookup are additional utility commands that also search DNS information and provide cross-referencing. These services are often free on the Internet and can be located by searching on the command name itself.

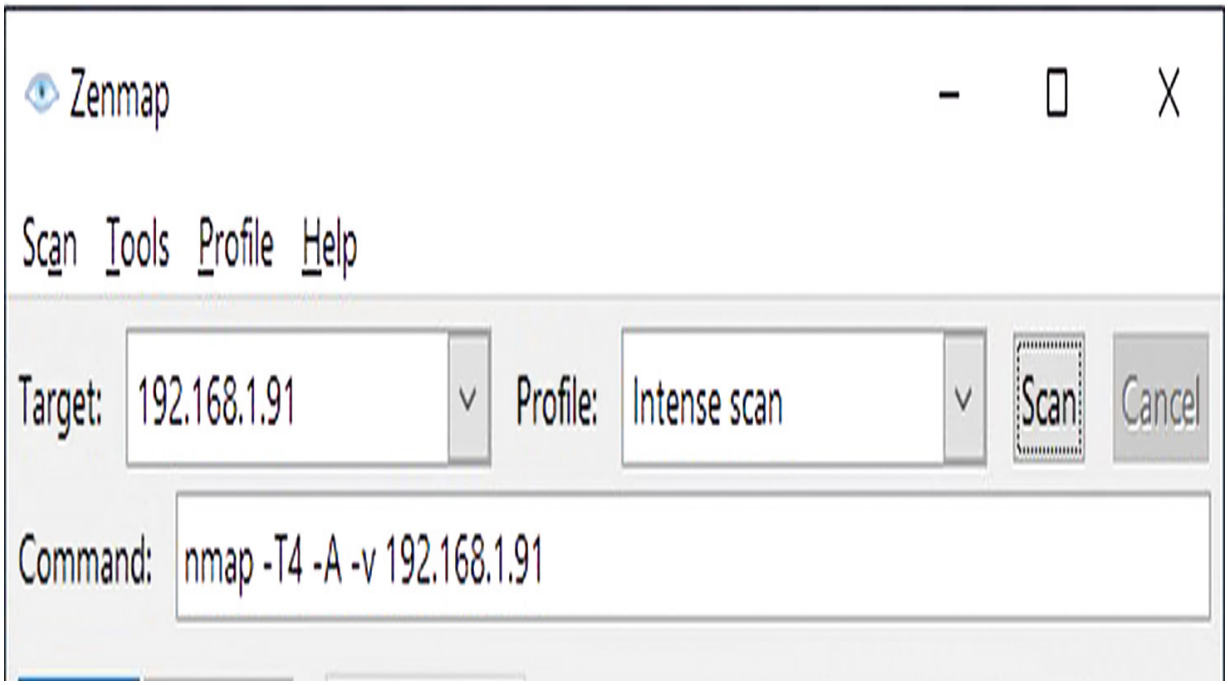
The ICMP ping command and several closely related tools are readily available on most computer operating systems. These profiling tools enable attackers to verify that target systems are reachable. For example, attackers can use the ping command with a number of extension flags to test direct reachability between hosts as well as using the ping command as part of the actual attack plan, for example, to carry out a ping-of-death attack whereby an attacker sends specially constructed ping packets that can crash vulnerable computers. Once a target network has been located, many attackers then perform a ping sweep of all (or a range of) IP addresses within the major network or subnet, to identify other potential hosts that may be accessible. Sometimes, this information alone exposes the likely network size and topology as well as pointing to likely server and network device locations because many networks use a structured numbering scheme.

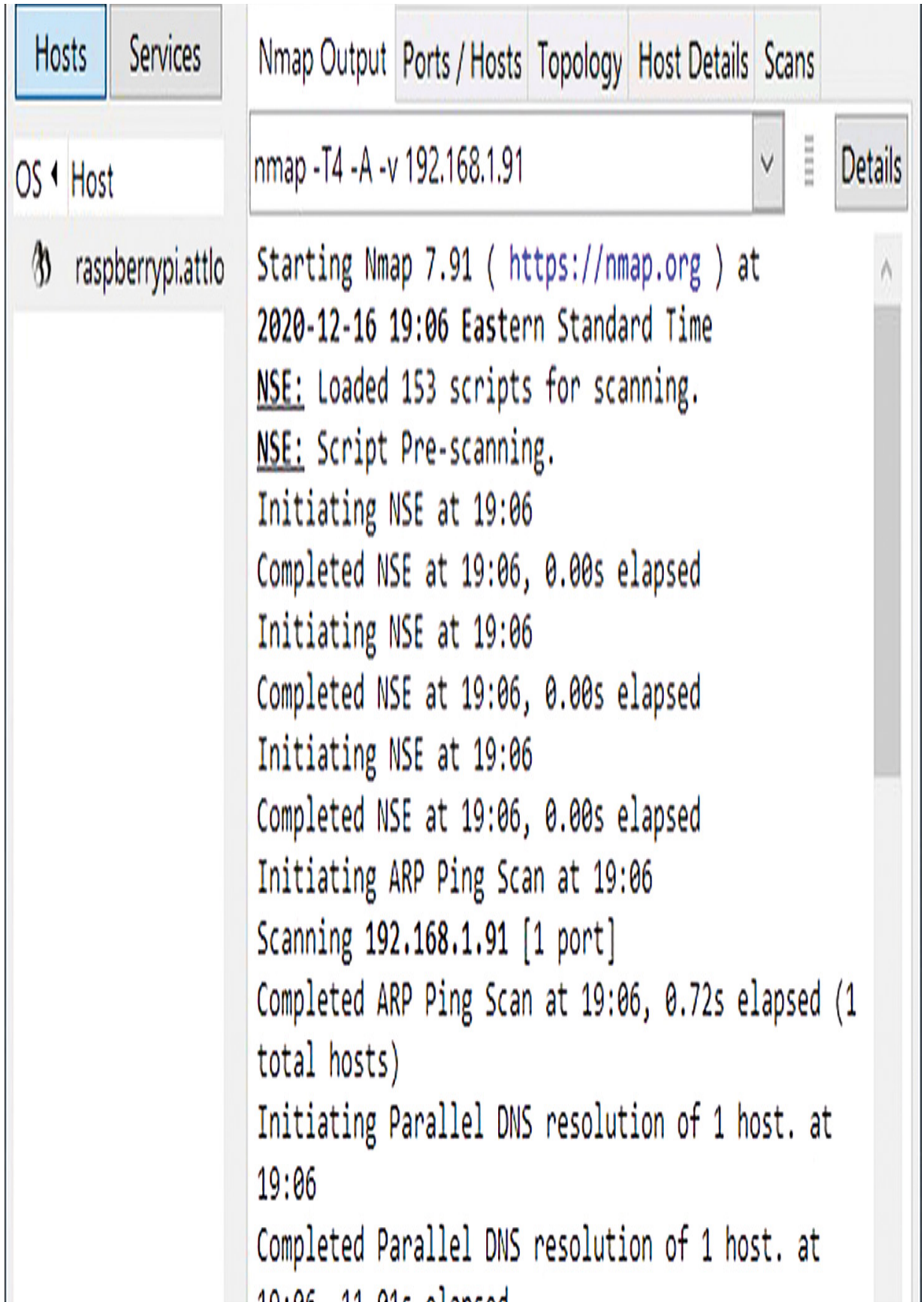
If gaining access is one of the objectives, an attacker can attempt a simple telnet logon to test the softness of perimeter controls. An attacker might also use rpcinfo to determine whether the remote procedure call (RPC) service is active for remote command execution.

SNMP Tools. SNMP is an Application Layer protocol that facilitates the exchange of management information between network devices and is part of the TCP/IP suite. SNMP enables network administrators to manage network performance, find and solve network problems, and plan for network growth.

Many popular network management software suites, such as OpenNMS®, PRTG® Network Monitor, and Progress WhatsUp® Gold, are SNMP compliant and offer full support for managed devices, agents, and network management systems. In addition, there are many utility programs that can be used to gather network device information, including platform, operating system version, and capabilities. Poorly configured network management facilities would allow moderately skilled attackers to gather significant attack profile information.

Port-Scanning and Port-Mapping Tools. After an attacker identifies a target network, the next step might be to explore what systems and services are accessible. To achieve this goal, an attacker might use several popular port-scanning applications, of which one of the most popular is Nmap Security Scanner®, which is available for UNIX, Linux, and Windows. Angry IP Scanner is another network reconnaissance tool, this one for Windows, Linux, and macOS. By design, it's fast and easy to use. **FIGURE 8-16** shows Zenmap®, a Windows GUI (graphical user interface) front end for the Nmap port-scanning tool.




Hosts
Services
Nmap Output
Ports / Hosts
Topology
Host Details
Scans
OS
Host
nmap -T4 -A -v 192.168.1.91
Details
raspberrypi.attlo
Starting Nmap 7.91 (https://nmap.org) at
2020-12-16 19:06 Eastern Standard Time
NSE: Loaded 153 scripts for scanning.
NSE: Script Pre-scanning.
Initiating NSE at 19:06
Completed NSE at 19:06, 0.00s elapsed
Initiating NSE at 19:06
Completed NSE at 19:06, 0.00s elapsed
Initiating NSE at 19:06
Completed NSE at 19:06, 0.00s elapsed
Initiating ARP Ping Scan at 19:06
Scanning 192.168.1.91 [1 port]
Completed ARP Ping Scan at 19:06, 0.72s elapsed (1
total hosts)
Initiating Parallel DNS resolution of 1 host. at
19:06
Completed Parallel DNS resolution of 1 host. at

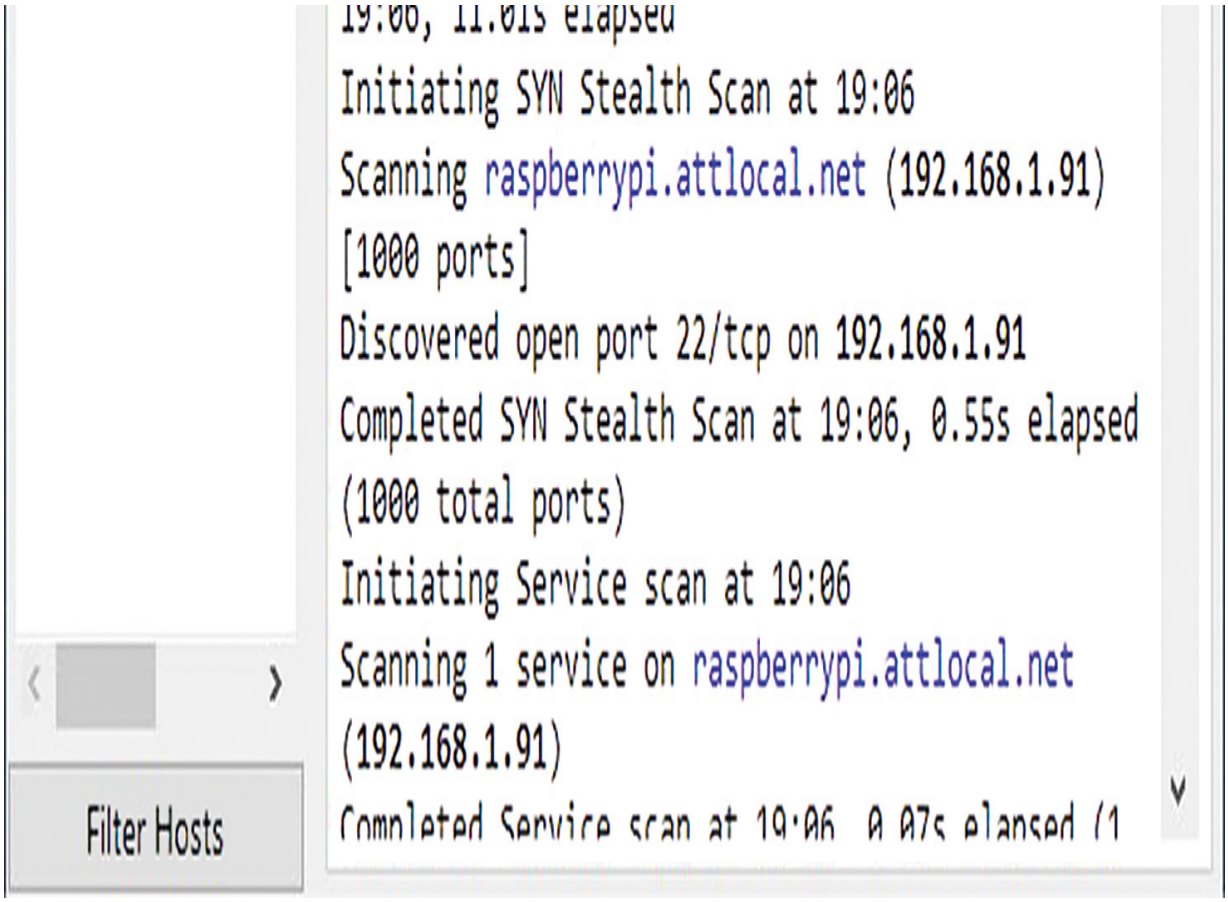

19:06, 11.01s elapsed
Initiating SYN Stealth Scan at 19:06
Scanning raspberrypi.attlocal.net (192.168.1.91)
[1000 ports]
Discovered open port 22/tcp on 192.168.1.91
Completed SYN Stealth Scan at 19:06, 0.55s elapsed
(1000 total ports)
Initiating Service scan at 19:06
Scanning 1 service on raspberrypi.attlocal.net
(192.168.1.91)
Completed Service scan at 19:06, 0.07s elapsed (1
Filter Hosts

FIGURE 8-16 Zenmap, a Windows GUI front end for the Nmap port-mapping tool.

These tools permit an attacker to discover and identify hosts by performing ping sweeps, probing for open TCP and User Datagram Protocol (UDP) service ports, and identifying operating systems and applications running.

Security Probes. Nessus® or its open source variant, OpenVAS, helps security administrators evaluate a large number of vulnerabilities. It recognizes several common networking, operating system, and application-related security problems and can report the problems without actually exploiting them. Nessus and OpenVAS collect information available to anyone with access to the network. With a properly configured firewall in place, security professionals can properly implement policies to protect information from unauthorized access. Each of these tools is a double-edged sword, however, in that, just as with many other tools, attackers can use them as easily as security professionals can. It is a good idea to include scanning for evidence of Nessus or OpenVAS reconnaissance of a network.

Access and Privilege Escalation

Once attackers profile and probe a target network for potential vulnerabilities, they must access the target system(s). The primary goal of access is to establish the initial connection to a target host (typically a server platform). To conduct additional reconnaissance activities, such as covertly installing hacking toolkits, the attacker must then gain administrative rights to the system.

The method of access depends on the connection technology necessary to reach the target network. As many organizations evolve to web-centric and cloud-based business models, sometimes they maintain legacy dialup access infrastructures, either as secondary remote gateways or due to oversight. In some instances, organizations may not even be aware of modem facilities left connected to outside phone lines or private branch exchanges (PBXs). Not all PBXs are outdated, though, and, in fact, many current organizations use hybrid systems that include either traditional or software PBX systems to provide resiliency. Today, most voice communication occurs using the IP network, and the PBX provides communication continuity in case the IP solution fails. As dialup modems are becoming rare in today's IT infrastructures, another nuisance is personnel attaching unauthorized wireless access points to the internal network. These rogue access points make it easy to connect multiple wireless devices, but compromise existing network perimeter defenses, and provide another entry point for malware attacks.

Password Capturing and Cracking

One method of gaining access to a network or other protected resource is to capture or crack passwords. An attacker can install a password logger as a backdoor Trojan on a target machine and monitor specific protocol and program activity associated with remote logon processes. Alternatively, if the attacker captures logon strings remotely, a program such as L0phtCrack (*www.l0phtcrack.com*) can quickly decrypt and compromise administrator and user passwords. In fact, compromising passwords is so attractive that many attackers have become quite resourceful at this task and have identified existing computer hardware that works well at password cracking. Many newer personal computers have

powerful graphics processing units (GPUs) on their video cards, which are designed to handle the advanced math calculations required for rendering graphic images. Attackers have found that GPUs also work well in cracking passwords because many of the new password-cracking tools offload much of the math to video card GPUs to speed up the process.

Maintaining Access Using a Remote Administration Tool

Remote Access Tool (RAT) is a Trojan that, when executed, enables an attacker to remotely control and maintain access to a compromised computer. This is done via one of the following:

- **A server on the victim's machine**—This server listens for incoming connections to the victim and runs invisibly, with no user interface. When it receives a connection, it provides remote access for the client that connects.
- **A client on the attacker's machine**—This is a GUI front end that the attacker uses to connect to and manage servers on victims' machines.

What happens when a server is installed on the victim's machine depends on the capabilities of the Trojan; the interests of the attacker; and whether another attacker, who might have entirely different interests, manages to gain control of the server.

Across all types of devices, including servers, workstations, IoT devices, and mobile devices, infections by remote administration are becoming as frequent as viruses. One common source is through file and printer sharing, which attackers can use to gain access to a hard drive. The attacker can then place the Trojan in the startup folder. The Trojan will then run the next time a legitimate user logs on. Another common attack method is to simply email the Trojan to the user. The attacker then uses social engineering to convince the user to run the Trojan.

Authors of these programs often claim that they are not intrusion tools but rather are simply remote-control tools or tools to reveal weaknesses in an operating system. Based on past activity, however, clearly their real purpose is to gain access to computers for unauthorized use.

Covering Traces of the Attack

One of the most important phases for an attacker to avoid detection is to remove any traces of an attack. Though the specific actions an attacker takes may differ from one attack to another, the basic steps are the same. First, experienced attackers attempt to remove any files they may have created and restore as many files to their preattack condition as possible. Second, the attackers will likely attempt to remove any log file entries that may provide evidence of the attack. This step is generally much more difficult than the first one because most systems use auditing methods that protect log files from modification, which means that attackers may have to attack the log files or the auditing system to erase their tracks. Regardless of the effort, cleaning any tracks they left behind greatly increases the likelihood that their attack will go unnoticed. Make sure that you protect detective security controls as well as other valuable assets. That way, even if you do not stop an attack, you can detect that it happened (or is currently happening).

Attack Prevention Tools and Techniques

IT security practitioners must understand how to implement effective countermeasures to defend against malicious code attacks. They must also continuously monitor, test, and improve these countermeasures.

Defense in depth is the practice of layering defenses into zones to increase the overall protection level and provide more reaction time to respond to incidents. It combines the capabilities of people, operations, and security technologies to establish multiple layers of protection, thus eliminating single lines of defense and effectively raising the cost of an attack. By treating individual countermeasures as part of an integrated suite of protective measures, you can ensure that you have addressed all vulnerabilities. Managers must strengthen these defenses at critical locations and then monitor attacks and react to them quickly.

With respect to malicious code threats, these layers of protection extend to specific critical defensive zones:

- Application defenses
- Operating system defenses
- Network infrastructure defenses

The goals of defense in depth are as follows:

- There should be layers of security and detection, even on single systems.
- Attackers must break through or bypass each layer undetected.
- Other layers can cover a flaw in one layer.
- Overall system security becomes a set of layers within the overall network security.
- Security improves by requiring the attacker to be perfect while ignorant.

Application Defenses

Software applications provide end users with access to shared data. Some of these data are sensitive or confidential and are not available to all users. To attempt to access or damage sensitive data, attackers commonly launch attacks on application software. Therefore, you should deploy appropriate controls to secure all application software running on all computers. Some common controls include the following:

- Implementing regular antivirus screening on all host systems
- Ensuring that virus definition files are up to date
- Requiring scanning of all removable media
- Installing firewall and IDS software on hosts as an additional security layer
- Deploying change-detection software and integrity-checking software and maintaining logs
- Implementing email usage controls and ensuring that email attachments are scanned
- Requiring all users to enable pop-up blockers in their web browsers to stop attackers from displaying pop-up windows and reducing exposure to accidental malware execution
- Establishing a clear policy regarding software installations and upgrades
- Ensuring that only trusted sources are used when obtaining, installing, and upgrading software through digital signatures and other validations

Operating System Defenses

The operating system serves as an interface between application software and hardware resources so that any attack that compromises the operating system can yield nearly unlimited access to system resources that store sensitive data. Successful attacks against the operating system can also allow an attacker to own a computer and use it for multiple purposes. Therefore, controls to secure the operating system are important. These controls include the following:

- Deploying change-detection and integrity-checking software and maintaining logs
- Deploying or enabling change-detection and integrity-checking software on all servers
- Ensuring that all operating systems are consistent and have been patched with the latest updates from vendors
- Ensuring that only trusted sources are used when installing and upgrading operating system code
- Disabling any unnecessary operating system services and processes that may pose a security vulnerability

Staying Ahead of the Attackers

Because most common anti-malware solutions can detect only known exploits, keeping the malware signature databases up to date is imperative. But what happens to attacks based on new exploits that are not in the malware signature databases? Attacks such as these are called zero-day attacks, based on the fact that initially they are undetectable using current malware signature databases. Once an attack has been reported, anti-malware software vendors must update their signature databases and release a security patch, after which users must then download and install the updated software or database. The time between these two events gives attackers a window of opportunity to conduct mostly unresisted attacks.

One way to combat malware, including zero-day attacks, is to use blacklisting and whitelisting, both of which act as additional layers of protection. *Blacklisting* means to maintain a list of all known dangerous sites so that any messages from a site in the blacklist are dropped. The main problems with blacklisting are keeping the blacklist up to date and the fact that any site that is blacklisted by mistake will have its access dramatically decreased, with multiple would-be customers ignoring connections and network messages. To make matters even worse, attackers are very good at frequently changing host or site addresses, which requires constant updating of a blacklist.

Whitelisting is the exact opposite of blacklisting. Instead of listing known dangerous sites, only trusted sites are listed so that all messages and connection requests from sites *not* in the whitelist are ignored. Even though whitelisting is safer than blacklisting, it is more restrictive, meaning that, before connections are allowed, all trusted sites must be added to the whitelist.

Network Infrastructure Defenses

At some point, nearly all computers and devices in today's organizations connect to a network, and, because networks make it easier to access targets remotely, most attacks on computers and devices are possible. Furthermore, malware almost always uses networks to spread, and, because networks are necessary for end-user access, the networks themselves can be targets. Therefore, you must deploy controls to protect the network, including the following:

- Creating chokepoints in the network
- Using proxy services and bastion hosts to protect critical services
- Using content filtering at chokepoints to screen traffic
- Ensuring that only trusted sources are used when installing and upgrading operating system code
- Disabling any unnecessary network services and processes that may pose a security vulnerability
- Maintaining up-to-date IDS signature databases
- Applying security patches to network devices to ensure protection against new threats and to reduce vulnerabilities

One of the simplest prevention techniques is to disable unnecessary network services, especially certain TCP and UDP listening ports, because doing so will defeat any attack that focuses on exploiting those services. This technique may not be efficient, though, if those services are required for legitimate users.

You can employ a wide variety of countermeasures and practices to prevent malicious code attacks on network resources. These include the

following:

- Employing filtering software that blocks traffic to and from network segments or specific services
- Employing active sensors (e.g., intrusion detection and antivirus detection) that react quickly enough to prevent or mitigate damage
- Employing chokepoints in the network to force traffic to flow through zones of protection
- Allowing sensors and filters to inspect traffic before permitting it to pass into the protected network
- Setting security properties within browsers to prohibit or prompt before processing scripts and active code
- Eliminating unnecessary remote connections to the network and employing effective access control measures to protect those required to remain available
- Avoiding the circumvention of existing control systems and countermeasures

Although these suggestions are valid, implementing them for all network devices is becoming increasingly difficult because of the proliferation of new types of network-connected devices, such as appliances, vehicles, environmental sensors and controls, and even wearable accessories. Moreover, keeping all of these devices (and the networks they connect to) secure is becoming more difficult due to the speed at which the number of networked devices is growing.

Safe Recovery Techniques and Practices

Regardless of how effective an organization's countermeasures are, the organization likely will eventually encounter some type of data loss due to malware. Its ability to recover from data loss depends on how well its security professionals have prepared for that situation. An organization cannot completely recover from a data loss unless it can ensure a completely malware-free recovery process. Following are a few guidelines to help you ensure that recovery media and procedures do not reintroduce any malware:

- Consider storing operating system and data file backup images on external media to ease recovering from potential malware infection.
- Scan new and replacement media for malware before reinstalling software.
- Disable network access to systems during restore procedures or upgrades until the protection software or services have been re-enabled or installed.

Implementing Effective Software Best Practices

All organizations should adopt an acceptable use policy (AUP) for network services and resources. A good AUP includes prohibitions on certain network activities and computer user habits regarding software licensing and installation as well as procedures for transmitting files and media. Adopt standardized software so that you can control patches and upgrades to ensure that you address vulnerabilities.

Consider implementing a security policy that is compliant with ISO/IEC 27002, which is the most widely recognized security standard. Compliance with ISO/IEC 27002, or indeed any detailed security standard, is a far-from-trivial undertaking, even for the most security conscious of organizations, and certification can be even more daunting. You can find out more at *www.iso27001security.com/html/27002.html*.

Intrusion Detection Tools and Techniques

Every organization should deploy a defense-in-depth approach in critical areas of its network as an early warning system. One of the integral components of that approach is intrusion detection tools, of which there are various implementations, each one having features that provide unique capabilities to protect networks and hosts from malicious activity.

A layered defense-in-depth approach would suggest deploying both network- and host-based intrusion detection as well as deploying products that permit both signature- and anomaly-based detection schemes.

Antivirus Scanning Software

Today, most computer users employ some form of virus protection to detect and prevent infection, whereas many mobile device users do not. Several surveys indicate that fewer than half of all users have basic security and antivirus software on their mobile devices. Just as you can layer intrusion detection at the host and network levels, you should deploy antivirus protection on all devices that support it.

NOTE

Anomaly detection involves developing a network baseline profile of normal or acceptable activity, such as services or traffic patterns, and then measuring actual network traffic against this baseline. This technique might be useful for detecting attacks, such as DoS or continuous logon attempts, but it requires a learning or preconfiguration period.

Following are the key vulnerabilities to host-based antivirus software:

- The continuing requirement to keep every host system updated to the most current virus definition files
- Potential compromise of the protection through unsafe user practices, such as installing unlicensed or unauthorized software or indiscriminately exchanging infected email or document files

Network-based antivirus software is an option that permits screening of files and email traffic on servers and provides remote scanning and inoculation of clients on a consistent basis.

Many organizations employ both network- and host-based protection, and some deploy multiple products in order to maximize detection capabilities. It is imperative that you keep virus definition files up to date; therefore, to help with this important task, most vendors now offer automatic updating of software as soon as they release new definitions.

Network Monitors and Analyzers

To ensure that security practices remain effective, you should regularly monitor network software and appliances as well as periodically analyze network traffic. Every so often, run a vulnerability scanner such as Nessus or OpenVAS. Keep in mind that attackers use these tools as well to try and find vulnerabilities before they are mitigated. You should scan the network for unnecessary open service ports on a regular basis because upgrades to software often reset systems to their default settings.

Content/Context Filtering and Logging Software

You must balance privacy and security when implementing countermeasures that filter content. When combined with a clear corporate policy on acceptable use, however, this becomes an additional layer of defense against malicious code. Plug-ins to screen email attachments and content, as well as context-based filtering (access control lists) on network routers, also permit an additional layer of security protection.

Content-based filtering includes analyzing network traffic for active-code components (e.g., Java and ActiveX) and disabling script processing on web-browser software. Context-based filtering involves comparing patterns

of activity with baseline standards so that you can evaluate unusual changes in network behavior for possible malicious activity.

Honeypots and Honeynets

The purpose of **honeypots**, which are sacrificial hosts and services deployed at the edges of a network, is to act as bait for potential hacking attacks and to provide a controlled environment for when such attacks occur. Typically, these systems are configured to appear real and, in fact, may be part of a *honeynet*, which is a suite of servers placed in a network separated from the real network. This controlled environment enables you to easily detect and analyze the attack to test the strength of the network. You install host-based intrusion detection and monitoring software to log activity.

What Is a Honeynet?

Honeynets are groups of honeypots made to simulate real, live networks and are beneficial because they provide more data and are more attractive to attackers. However, the setup and maintenance requirements of a honeynet are a little more advanced because it may include many servers, a router, and a firewall. A honeynet may be identical to the production network, or it might be a research lab. Either way, honeynets allow for a more real environment for an attacker to attack.

All traffic to and from the honeypot is suspicious because the honeypot contains no production applications. A few logs, which should be easy to read and understand, should be produced on the honeypot unless it is under heavy attack. When attackers probe honeypots, administrators can place preventive controls on their real production networks.

A honeypot should contain at least the following elements:

- It looks and behaves like a real host.
- At no point should it disclose its existence.
- It has a dedicated firewall that prevents all outbound traffic in case it is compromised.

- It lives in a network demilitarized zone (DMZ), untouched by normal traffic.
- It sounds silent alarms when any traffic goes to or from it.
- It begins logging all intruder activity when it first senses an intrusion.

A low-involvement honeypot provides a number of fake services, such as HTTP or SMTP, and allows attackers to connect to services but do nothing else. With this type of honeypot, an attacker usually cannot gain operating system access and, therefore, poses no threat.

Contrarily, a high-involvement honeypot produces genuine services and vulnerabilities by providing a real operating system for the attacker. The purpose of this class of honeypot is for attackers to compromise it so you can collect realistic data. The problem with these honeypots is that you must tightly control the environment because, if a system is compromised, it can become a host to begin an attack on another system.

CHAPTER SUMMARY

In this chapter, you learned about the different types of malware and how each type operates. Moreover, you learned about viruses, spyware, and ransomware and their effect on today's organizations; the dangers of keystroke loggers, hoaxes, and webpage defacements; and the history of malware and how threats have emerged for today's organizations. Finally, you learned about different types of system, application, and network attacks and how attackers use tools to carry them out.

KEY CONCEPTS AND TERMS

Active content
Backdoor
Botnet
Browser add-on
Cookie
Defense in depth
Denial of service (DoS) attack
Honeypot
Injection technique
Keystroke logger
Logic bomb
Macro virus
Malicious code
Malicious software
Malware
Ransomware
Rootkit
Spam
Spyware
Trojan
Virus
Worm

CHAPTER 8 ASSESSMENT

1. Which type of malware attaches to, or infects, other programs?
   A. Spyware
   B. Virus
   C. Worm
   D. Rootkit
2. _____ is any unwanted message.
3. Which type of malicious software is a stand-alone program that propagates from one computer to another?
   A. Spyware
   B. Virus
   C. Worm
   D. Snake
4. In the context of malware, which of the following best defines the term *mobile code*?
   A. Website active content
   B. Malware targeted at tablets and smartphones
   C. Software that runs on multiple operating systems
   D. Malware that uses networks to propagate
5. A(n) _____ is a network of compromised computers that attackers use to launch attacks and spread malware.
   A. Black network
   B. Botnet
   C. Attacknet
   D. Trojan store
6. What does the TCP SYN flood attack do to cause a DDoS?
   A. Causes the network daemon to crash
   B. Crashes the host computer
   C. Saturates the available network bandwidth
   D. Fills up the pending connections table

7. Which type of attack tricks a user into providing personal information by masquerading as a legitimate website?
   A. Phreaking
   B. Phishing
   C. Trolling
   D. Keystroke logging
8. The best defense from keystroke loggers is to carefully inspect the keyboard cable before using a computer because the logger must connect to the keyboard's cable.
   A. True
   B. False
9. How did viruses spread in the early days of malware?
   A. Wired network connections
   B. Punch cards
   C. Diskettes
   D. As program bugs
10. What is the most common first phase of an attack?
    A. Vulnerability identification
    B. Reconnaissance and probing
    C. Target selection
    D. Evidence containment
11. Which software tool provides extensive port-scanning capabilities?
    A. Ping
    B. Whois
    C. Rpcinfo
    D. Nmap
12. The _____ strategy ensures that an attacker must compromise multiple controls to reach any protected resource.
13. A honeypot is a sacrificial host with deliberately insecure services deployed at the edges of a network to act as bait for potential hacking attacks.
    A. True
    B. False

CHAPTER 9
Security Operations and Administration

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SECURITY PROFESSIONALS MUST UNDERSTAND how security operations and administration create the foundation for a solid security program. Your role as a security professional is similar to that of a coach. You work with staff to identify the strengths and weaknesses of your "players," or assets, and your goal is to win the game, which, in the world of the security professional, is to secure your organization's resources. Your "opponents" are unauthorized users trying to crash your systems or steal your data and use it against you.

As a coach, you know the rules, and you have a playbook of strategies, which you need to keep out of the hands of your opponents. You also need to make sure your strategies abide by the rules and regulations of the industry. You have to play by the rules, but that does not mean your opponents will. To prepare your players for the challenge, you must educate and train them, so they have the skills they need to work together as a team to win the game.

If you are successful, your organization will run as smoothly as a championship team, and everybody will understand the mission and how to work together to complete it. If you are not prepared, your team will appear confused. Players will seem to be doing their own thing, regardless of the consequences. The next thing you know, your organization's information will fall into the hands of your opponents, and your systems will not work the way they are supposed to. Your trade secrets will no longer be secret, your organization will spend a lot of money fixing what's broken, and you and your employees might find yourselves "on the bench" or even looking for other jobs.

Everyone wants to be on a winning team. In this lesson, you will learn the skills needed to develop a strong security administration team.

Chapter 9 Topics

This chapter covers the following topics and concepts:

- What security administration is
- What compliance is
- What professional ethics are
- What the infrastructure for an information technology (IT) security policy is
- What data classification standards are
- What configuration management is
- What the change management process is
- What the system life cycle (SLC) and system development life cycle (SDLC) are
- How software development relates to security

Chapter 9 Goals

When you complete this chapter, you will be able to:

- Develop and maintain security programs
- Understand and use professional ethics
- Promote user awareness of security
- Create and support policies to govern the security infrastructure
- Classify data
- Control major and minor changes to systems
- Understand how the SLC and SDLC promote security

Security Administration

Security administration within an organization refers to the group of individuals responsible for planning, designing, implementing, and monitoring an organization's security plan, and the physical location where they work is often referred to as the **security operations center (SOC)**. Even though it is not required that the SOC team work in a central location, it often does, where there are several large video screens that display real-time operational status of networks and information systems. With today's remote and distributed workforce, it is possible for a geographically diverse SOC team to work closely to maintain environmental security, but that's not all the SOC team members are responsible for. They work as a cohesive unit to share information, experience, and insight to collectively assess prevailing conditions, recommend actions as conditions change, and implement those changes.

As early SOC teams struggled to manage the growing volume of information about networks and systems, they began to accumulate and integrate useful tools, which grew into a tool set called security information and event management (SIEM) systems. SIEM provides a rich, integrated set of tools to help collect, assess, and visualize a networked environment's state. The latest extension to the SOC toolbox is a superset of tools that includes SIEM and others, used to organize and manage the response to security incidents. A security, orchestration, automation, and response (SOAR) system gives the SOC team an integrated set of tools with which to determine the security level of a networked environment, identify any anomalies, and respond to any issues in a structured manner.

Before you can form an administrative team, though, the organization must identify and document its information assets, after which, you should assign each responsibility to a person or position. This administrative team then determines the sensitivity of each asset so that it can plan how to secure each one accordingly.

Controlling Access

A primary task of an organization's security administration team is to control access to systems or resources. There are four aspects of access control:

- **Identification**—Assertions made by users about who they are
- **Authentication**—The proving of that assertion
- **Authorization**—The permissions a legitimate user or process has on the system
- **Accountability**—Tracking or logging what authenticated and unauthenticated users do while accessing the system

The security administration team leads these efforts by determining the best security controls to implement to secure an organization's resources.

Documentation, Procedures, and Guidelines

The security administration team handles the planning, design, implementation, and monitoring of an organization's security program. To make the best decisions to secure assets, several types of documentation are necessary to provide the input the security administration team needs. The most common documentation requirements include the following:

- **Sensitive assets list**—What assets must the organization take measures to secure? The list can include computers, devices, network components, databases, documents, and any other assets that could be vulnerable to attack.
- **The organization's security process**—How does it all work?
- **The authority of the persons responsible for security**—Which administrator is responsible or authorized for what assets and actions?
- **The policies, procedures, and guidelines adopted by the organization**—What information needs to be communicated, how is it communicated, and when is it communicated?

The security administration team puts together all the pieces of a puzzle to ensure the organization complies with stated policies. An organization must comply with rules on two levels:

- **Regulatory compliance**—The organization must comply with laws, government regulations, and contractual requirements.
- **Organizational compliance**—The organization must comply with its own policies, audits, culture, and standards.

As a result, the security administration team's documentation, procedures, and guidelines focus on compliance and compliance monitoring. The team members must ensure that the organization follows the various rules and regulations.

Disaster Assessment and Recovery

The security administration team's responsibilities include handling events (e.g., incidents, disasters, and other interruptions) that affect an organization's computers, devices, and networks. To handle these events, the security administration team forms an incident response team, which comprises individuals who are responsible for responding to incidents and investigating security breaches. Moreover, the security administration team also manages the emergency operations group, which is responsible for protecting sensitive data in the event of natural disasters and equipment failure, among other potential emergencies.

Despite the best efforts of the incident response team, the emergency operations group, and system administrators, all systems are still subject to failure or attack. Therefore, the best a security administration team can do is to ensure that an organization can respond rapidly and effectively to any event.

Security Outsourcing

Many organizations rely on outside firms to handle security monitoring and analysis, which means you might need to monitor the work of the outsourcing firm or work with it as an external entity when handling incidents. This approach has both advantages and disadvantages:

- **Advantages**—An external security management firm has a high level of expertise because it focuses on security—and security only—every day.

Simply put, it will have expertise and experience that an organization alone might not have.

- **Disadvantages**—Outsourcing has two primary disadvantages. First, the outsourcing firm might not know the organization well nor possess enough internal knowledge necessary to protect its assets. Second, by outsourcing, the organization will not be developing its own in-house capability or talent and will therefore need to continue to pay for these services indefinitely.

Outsourcing Considerations

The security administration team and an outside firm must work together closely to make sure they agree to specific security requirements. Integrating data or processing with third parties introduces new threats, and relocating data or processes (or both) outside of an organization's own data centers raises trust questions. How can you trust another organization to protect your intellectual property? Though there are many concerns to address when outsourcing, the main concerns include the following:

- **Privacy**—Does the third party agree to uphold the organization's privacy policy? How does it plan to control how data is collected, stored, handled, and destroyed?
- **Risk**—What additional risks exist by transferring data over a trust boundary? How are any new risks addressed? Who is responsible for managing new outsourcing risks?
- **Data security**—What controls protect data confidentiality and integrity from unauthorized access? Are access controls consistent with internal controls? How is data availability protected? Are backups and redundancy measures in place to minimize downtime? How are backups and redundant data copies protected?
- **Ownership**—Who owns the data, the infrastructure, and the media? Who is responsible for each component?
- **Adherence to policy**—Does the third party commit to upholding the organization's security policies and procedures?

Several types of agreements that help to formalize answers to the preceding questions are common when outsourcing to external organizations. A list of

the most common agreements that define how an outsourcing relationship works would include the following:

- **Service level agreement (SLA)**—This type of agreement is a legally binding formal contract between an organization and a third-party external organization that details the specific services the third party will provide. Following are examples of security-related services detailed in an SLA:
    - How and when potential security breaches are identified and communicated
    - How logs and events are reported
    - How confidential data is handled
    - What the security system uptime requirements are (e.g., an organization might require that all critical security systems have a 99.99 percent reliability)

The SLA should communicate the expectations and anticipate the needs of both the organization and the outside firm. Individual members of the security administration team must thoroughly analyze their department's risks because any risk unaccounted for is likely to cost an organization in terms of either data loss or expenses to fix it. You can compare this situation to maintaining an automobile: Regular oil changes are less expensive than blown head gaskets, so maintaining an engine is cheaper than fixing one.

- **Blanket purchase agreement (BPA)**—As a streamlined method of meeting recurring needs for supplies or services, a BPA creates preapproved accounts with qualified suppliers to fulfill recurring orders for products or services.
- **Memorandum of understanding (MOU)**—Also called a letter of intent, an MOU is an agreement between two or more parties that expresses areas of common interest that result in shared actions. MOUs are generally less enforceable than a formal agreement but still more formal than an oral agreement.
- **Interconnection security agreement (ISA)**—Often an extension of an MOU, an ISA documents the technical requirements of interconnected

assets. This type of document is most often used to specify technical needs and security responsibilities of connected organizations.

The negotiation process and creation of agreements is one of the first steps in the business partner onboarding process. Any time an organization decides to outsource data or processing, it must carefully consider the security impact and responsibilities, and the onboarding process is just the time to plan for contingencies before a problem occurs. Moreover, it provides the opportunity to clearly communicate goals and expectations for all parties. Likewise, you should specify an offboarding process to follow when you terminate relationships with outsourced resources. This process defines how to transfer control of data and other assets, terminate communications, and complete any open transactions and is necessary to ensure that no remnants of data or processing remain once an outsourcing relationship ends.

Compliance

An organization's security policy sets the tone for the way you approach security activities and states the rules with which you must comply. Think of a security policy in terms of traffic laws, whose purpose is to maintain a certain degree of order and safety on the roads, but only if they are enforced; otherwise, the roads can become dangerous. Likewise, an information security policy must be enforced to be effective in protecting assets. When policies are enforced, the organization complies with them. Three primary means are used to ensure compliance:

- Event logs
- Compliance liaison
- Remediation

Event Logs

Event logs are records of actions that an organization's operating system or application software creates, showing which user or system accessed data or a resource and when. You can think of event logs as being similar to the system a public library uses to keep track of who checks out books: When a book is late or missing, the library checks its records to determine who last checked out the book. Likewise, when an information security breach occurs, an event log helps determine what happened to the system and when so that you can identify the culprit or fix the problem.

You can change the amount of information that event logs record. To record every event requires a tremendous amount of disk space and will probably slow down an organization's computers as well as making reading through the log files more difficult because there is so much data to examine. Contrarily, logging too few events may cause some important details to slip through the cracks. Therefore, it is important to record all the actions that you may need in the future to investigate security problems. Another concern is to ensure that access to the event logs is controlled because you do not want an

attacker to be able to compromise the system and then erase any trace of the attack.

Compliance Liaison

As organizations and security policies become larger and more complex, staying compliant becomes more difficult. Therefore, organizations employ **compliance liaisons** whose responsibility is to make sure that all personnel are aware of—and comply with—the organization's policies. Because departments within an organization might have their own security ideas or needs different from other departments', a compliance liaison works with each department to ensure it understands, implements, and monitors compliance applicable to it. Moreover, a compliance liaison can also help departments understand how to include information security in their daily operations.

Another important role of a compliance liaison is to review agreements throughout any outsourcing engagement to ensure the rules that were established in the interoperability documents are being followed. This review helps validate whether a service provider is in compliance with current agreements. As compliance has become more and more important, many organizations have expanded executive leadership roles to include a chief security officer (CSO) or chief information security officer (CISO). A CSO/CISO provides guidance to executives in matters related to security. In organizations with a CSO/CISO, the compliance liaison works under that person's guidance.

Remediation

Mitigating vulnerabilities reduces the risk of attacks against an organization's computers and networks. In some cases, the best solution is to block an intruder and deny access to a resource, thus lessening the risk. In other cases, removing the vulnerability is possible through remediation. **Remediation** involves fixing something that is broken or defective, and, with computer systems, it refers to fixing security vulnerabilities.

Of course, some problems are more important than others; therefore, you should fix high-risk issues before lower-risk ones. When possible, the best

option is to remove a vulnerability altogether, but, if you cannot do so effectively, the next best step is to remove the ability of an attacker to exploit it.

You should always design security policies to protect your assets from attack, but not all organizations invest enough in security on their own. Several government bodies and industry governance groups have developed requirements that compel organizations to remediate certain types of vulnerabilities. Compliance requirements exist because a governance body recognized weaknesses and decided to mandate protection against those weaknesses. Complying with mandated requirements goes a long way toward helping organizations to become more secure and to avoid sanctions or penalties, whereas noncompliance can result in fines or other penalties that can limit an organization's ability to carry out business functions. Furthermore, most compliance requirements come with auditing or other monitoring requirements that allow auditors to determine compliance. Compliance is extremely important in securing information technology systems, but it is only the first step toward being secure. Think of checking all the compliance boxes and covering just the minimums. That is a great start, but you should strive to go beyond meeting compliance minimums.

Professional Ethics

Every respected profession has its own code of ethics and conduct, and adhering to such a code fosters the respect of any profession's practitioners. In this respect, the security profession is no different from other professions. Because people will not follow the rules if they do not trust the leaders, it is important that security professionals have a definite code of ethics that governs their behavior. Most security certification organizations publish their code of ethics, and, in fact, most certifications require candidates to commit to adhering to a specific code of ethics before qualifying for the certification. For example, both $(ISC)^2$ and CompTIA provide solid ethical guidelines. However, guidelines are not effective unless people adopt and practice them. Here are some tips for practicing strong ethics:

- **Set the example**—Security professionals must demonstrate strong ethical principles in their daily activities so that users will follow their lead. Being serious about ethics will help users to be serious also.
- **Encourage adopting ethical guidelines and standards**—Security professionals must know their ethical boundaries and set an example by adhering to them, which often means making difficult decisions and setting a good example. They must push the organization to define its code of ethics, which, in turn, helps the staff operate ethically and responsibly.
- **Inform users through security awareness training**—Security professionals must ensure that users are aware of and understand their ethical responsibilities.

Common Fallacies About Ethics

For security professionals, simply writing down a list of ethics-oriented rules is not enough; they must also apply ethics in their everyday lives. The first step in adhering to ethics rules is to understand the most common assumptions that many computer users hold that may lead them to unethical behavior. Here are some of these common assumptions:

- Users assume that computers should prevent abuse. If they can gain unauthorized access, it's the organization's fault—not theirs.
- Users believe that, in some legal systems, they have the right to explore security vulnerabilities as a form of free speech or expression.
- Users think their actions may cause only minor damage and that a little damage will not bother anyone.
- Users think that, if it's easy to break in, it must be all right to do so.
- Users think that hacking is okay if what they do is not damaging. They think that, if they are not making any money or otherwise advancing themselves by hacking into a system, they must not be committing a crime.
- Users think information should be free and that it's okay to look through somebody's system to obtain information.

Codes of Ethics

A code of ethics helps ensure professionalism, and there are several published codes that apply to information security. For example, published statements from the **Internet Architecture Board (IAB)** summarize the tone of most security-related codes of ethics and explain what the IAB considers ethical and appropriate behavior.

IAB Statement of Policy

The IAB has provided a list of unethical and unacceptable online practices, specifically related to activities involving the Internet. In 1989, the IAB issued RFC 1087, which is a statement of policy about Internet ethics. Although it was one of the first statements on the ethics of Internet use, it still applies today. RFC 1087 (*https://tools.ietf.org/html/rfc1087*) states that any activity is unethical and unacceptable that purposely does any of the following:

- "Seeks to gain unauthorized access to the resources of the Internet"
- "Disrupts the intended use of the Internet"
- "Wastes resources (people, capacity, computer) through such actions"
- "Destroys the integrity of computer-based information"

- "Compromises the privacy of users"
- "Involves negligence in the conduct of Internet-wide experiments"

The key point of the document is this: Access to the Internet is a *privilege*, not a right.

Professional Requirements

In any profession, rules and regulations enforce professional ethics, and sometimes, those rules come from certifying agencies, which means that, if you violate the rules, you risk losing your certification or license. In other contexts, laws and regulations require ethical behavior. For example, the Organisation for Economic Co-operation and Development (OECD) is an organization of more than 30 countries whose goal is economic cooperation and growth. In 1980, it created eight privacy principles, which have formed the basis for much of the world's privacy legislation. In summary, the principles state the following:

- An organization should collect only what it needs.
- An organization should not share its information.
- An organization should keep its information up to date.
- An organization should use its information only for the purposes for which it was collected.
- An organization should properly destroy its information when it is no longer needed.

NOTE

For more information about the OECD, visit www.oecd.org. You can find the latest "OECD Privacy Framework," which includes guidelines and their application in today's environments, at www.oecd.org/sti/ieconomy/privacy-guidelines.htm.

Technical TIP

As you have learned, many certification organizations require adherence to a code of ethics. You can find the (ISC)^2 Code of Ethics at *www.isc2.org/Ethics*. The CompTIA Candidate Code of Ethics is available at *www.comptia.org/testing/testing-policies-procedures/test-policies/continuing-education-policies/candidate-code-of-ethics*.

Personnel Security Principles

For all the technical solutions you can devise to secure an organization's systems, the human element remains your greatest challenge. You might be surprised how far a little education can go. If staff members are aware of how security risks can hurt both themselves and the organization, they will be more likely to help you run a tight ship.

It's important to know what a user should and should not do, and the best way to accomplish this goal is to create well-defined job descriptions, job roles, and responsibilities. When you know what people should be doing, it's easier to identify activities they are not supposed to do. If their roles or responsibilities are vague, it's more difficult to flag bad behavior, which means people are more likely to get away with things.

Minimizing access to information and assets is an important security control. Therefore, pay careful attention to any security concepts and controls that directly affect personnel. Because people are the most important assets in an organization, it is vital that they know how to contribute to maintaining the organization's security.

Limiting Access

When deciding how to grant access to users, one of the core principles is **least privilege**, which means limiting access to users based on the levels of permissions they need to perform their duties. Using this principle helps to keep unauthorized users from accessing information they should not be able to access. For example, weak access controls may allow a salesclerk to view employee salaries.

Another concept that relates to the principle of least privilege is the *need-to-know* requirement, which states that people should have access only to information they need to perform their jobs, regardless of their clearance level. The application of this principle means that, even though users might have a top-secret security clearance, they should not have access to *all* top-secret information, only the information they need to do their jobs.

Separation of Duties

Another security principle is **separation of duties**. This principle entails breaking a task into subtasks so that different users must carry them out; in other words, a user who plans to harm a system must get help from others, or form a conspiracy, which is hard to organize and to hide. For example, separation of duties in the context of vendor management helps prevent an employee from opening a bank account for Acme Consulting, going into the system at work to create a new vendor named Acme Consulting, and then cutting a check for $1,000 to Acme Consulting.

Job Rotation

Yet another way to protect against personnel-related security violations is to use **job rotation**, which minimizes risk by rotating employees among various systems or duties and thus prevents collusion (i.e., several employees conspire to commit fraud). It also gives managers a chance to track which users were authorized to take what actions and when. Therefore, if other security measures have failed, job rotation provides an opportunity to find the security breach before it inflicts more harm. Moreover, job rotation provides trained backup because several employees learn the skills of specific jobs.

Mandatory Vacations

Much like job rotation, **mandatory vacations** provide the chance to detect fraud. When users are on vacation, you should suspend their access to the organization's environment, thus preventing them from working from home, where they might attempt to cover their tracks. Moreover, under U.S. banking rules, for example, certain bank employees must take two consecutive weeks of vacation, and, until recently, the law forbade managers from contacting these vacationing employees with work-related matters. That rule has since

been relaxed to allow for read-only access to systems so that employees can at least keep up with their email correspondence. However, they still cannot participate in work-related activities while on vacation.

Security Training

Because personnel are so important to solid security, one of the best security controls you can develop is a strong security training and awareness program. Security training helps gain the support of all employees, who then become security advocates who are motivated to comply with policies that relate to their jobs and to be careful to avoid security breaches. Following their initial security training, employees should undergo repeated training at specified intervals, which refreshes employees' knowledge and reminds them of the importance of security. Well-trained personnel can make the difference between a secure environment and a collection of attacks and mistakes.

Employees should be aware of security threats (e.g., installing rogue technologies, selecting weak passwords, and phishing attacks) to an organization, especially from human factors. These types of threats are common because so many organizations fail to train their personnel on the importance of recognizing them. Simply explaining how weak passwords can endanger personal and business information can often encourage users to create stronger passwords.

Security Awareness

A security awareness program should address the requirements and expectations of an organization's security policy, which requires actions and provides authority for security controls, and is one of the best forms of defense. Employees are more likely to comply with a security control if they realize that the policy mandates it. In addition to explaining why each part of the policy is necessary, the program should explain the penalties for policy violations.

An awareness program is different from a formal training program. Most users do not understand what security is and why it's necessary. You can use security awareness programs—including posters, emails, and employee newsletters, among other tools—to do the following:

- Teach users about security objectives
- Inform users about trends and threats in security
- Motivate users to comply with security policies

Employees generally want to do what is best for the company, but they will often bypass security measures to complete their work more quickly when security seems to get in the way of their productivity. For example, suppose Bob, an employee, is home for the weekend and receives a call from Sue, an employee at the office, asking him for his password to get to a file so she can finish a project. In this situation, even though employees have been reminded over and over of the risks of sharing passwords, most of them will still be quick to reveal their password to others. Therefore, the security professional must reinforce the importance of employees' following security policies as well as teach them how to solve productivity problems and still maintain a high level of security.

Awareness programs do just that, by reminding staff about security policies. They can also measure how well the staff follows the security policy, provide staff with practical advice on how to deal with security incidents, and convince staff members that security is their personal duty. Such programs can help employees change their behavior so that security becomes a part of their daily routine.

Make note of employees who are not following policies, and use this information in a training session to present employees with scenarios that are specific to their work. Ask employees, "What would you do when _____?" The information you gather will help identify gaps in the awareness program so that you can tailor the program to address them.

Social Engineering

One of the most popular types of attacks on computer systems, as well as one of the most critical areas of security, involves social engineering, which entails deceiving or using people to get around security controls. Because most people want to be helpful, it is not too hard for attackers to convince those with system access to do something they should not do. And, as the number of employees with access to systems and data increases, the risk of security breaches increases further. However, technical solutions will not

stop an authorized user from calling an unauthorized person and reading sensitive data over the phone. Therefore, the best way to avoid social engineering is to train personnel train to recognize social engineering attempts and how to handle them. The security training should cover the most common types of social engineering attacks, including:

- **Intimidation**—Using threats or harassment to bully another person for information
- **Name-dropping**—Using the names of managers or superiors to convince another person that a higher authority has allowed access to information
- **Appeals for help**—Tugging at a person's sense of compassion or understanding of a difficult, and perhaps unreasonable, situation. The goal of the emotional appeal is to bypass normal procedures or gain special consideration, and when combined with an incentive, such as a reward, this type of engineering is very effective. For example, consider the scam in which scammers promise to send you money if you will help them transfer money to a disadvantaged person. Unfortunately, this type of emotional appeal fools many people every year.
- **Phishing**—Technology works quite well in social engineering, as, for example, with phishing. In a phishing attack, scammers create an email or webpage that resembles the work of a reputable organization, hoping that you believe it's the real organization so you will share sensitive information with them. They then use this information to gain access to your financial information or to steal your identity. A phishing attack can also take the form of a survey that asks questions in an effort to capture sensitive information.

NOTE

For more information about the latest phishing techniques and fraud alerts, see *www.fraudwatchinternational.com/phishing*.

The Infrastructure for an IT Security Policy

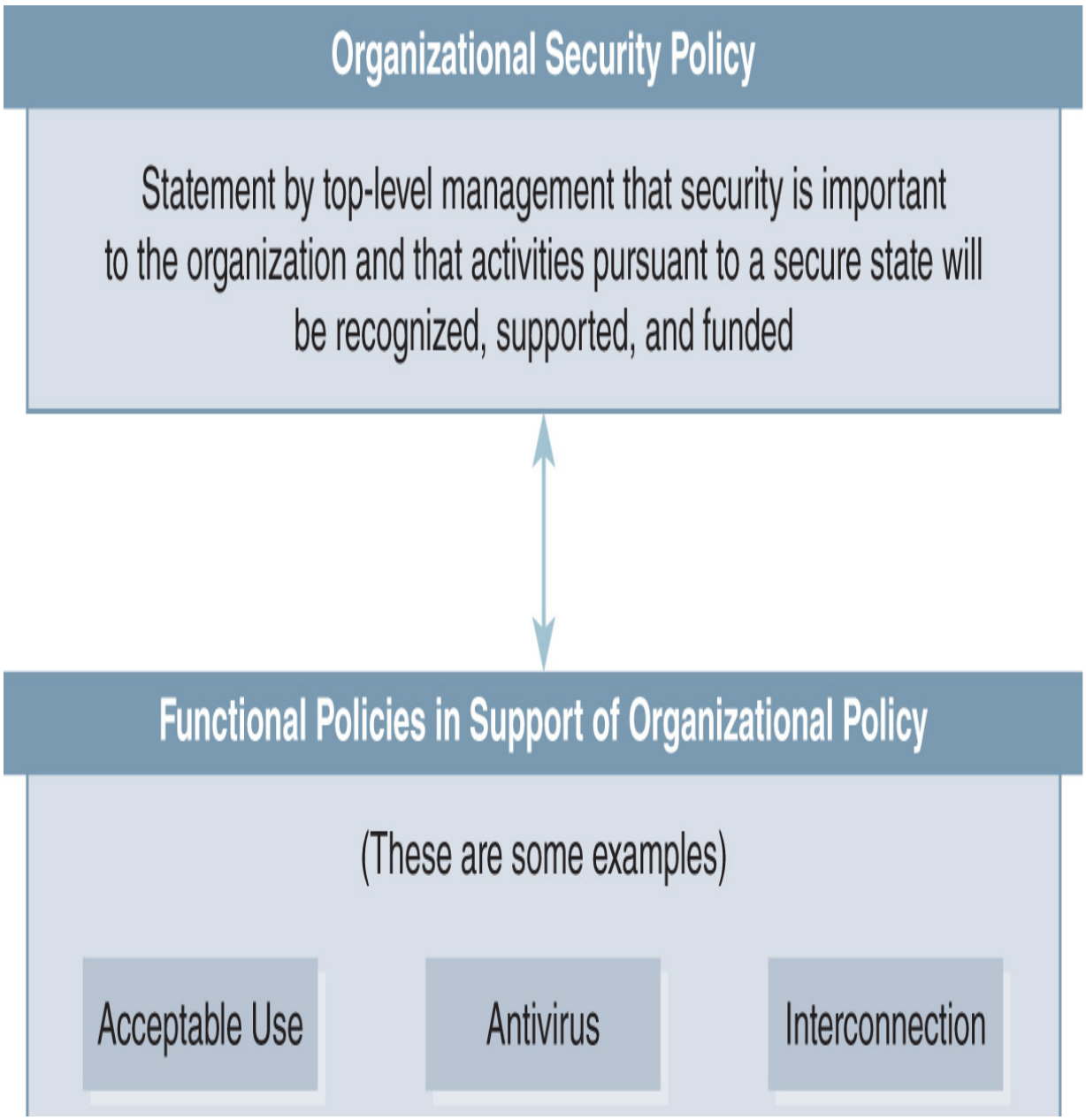
Every company operates within a complex combination of laws, regulations, requirements, competitor challenges, and partner expectations as well as being affected by morale, labor relations, productivity, costs, and cash flow. Within this environment, management must develop, publish, and maintain an overall security statement and directives. From the security team's perspective, a security program addresses these directives through policies and their supporting elements, such as standards, procedures, baselines, and guidelines. **FIGURE 9-1** shows the elements of a security policy environment.

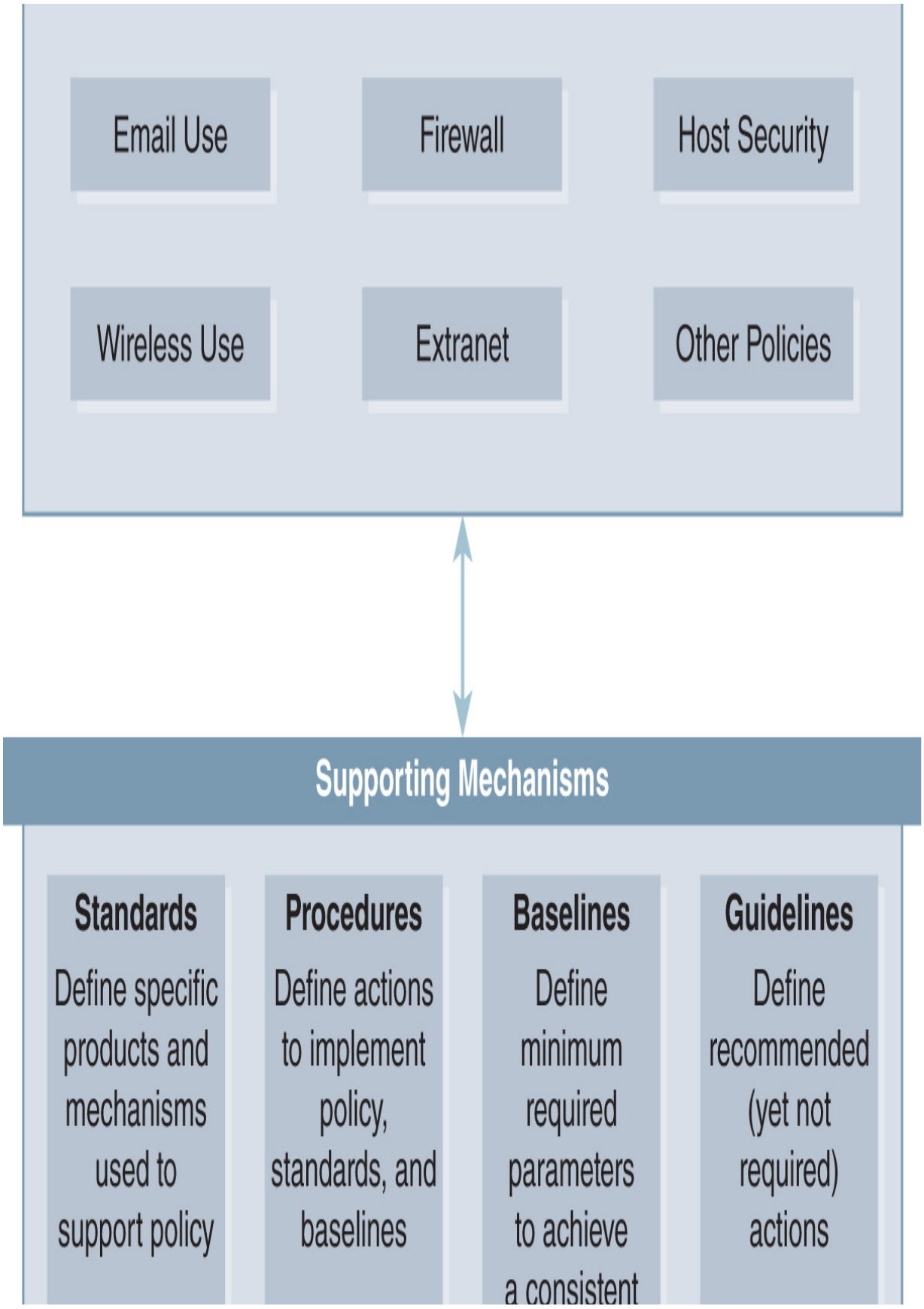
FIGURE 9-1 The security policy environment.

Each element has a specific requirement for security professionals, who are involved with compliance monitoring, security awareness, training, access control, privacy, incident response, log analysis, and more. The security policy sets the tone and culture of an organization, which means that security professionals are often required to apply policy intent by putting

what a policy says into action. Therefore, you must understand the details of the organization's security policy, which is the high-level statement of values and direction, supported and made possible by the organization's standards, baselines, procedures, and guidelines.

The role of the security professional is to provide support for these elements. This support includes informing personnel of policies, training, and enforcement when any policy element is violated as well as having a role in any updates or changes. **FIGURE 9-2** shows a typical security policy hierarchy.


Organizational Security Policy
Statement by top-level management that security is important to the organization and that activities pursuant to a secure state will be recognized, supported, and funded
Functional Policies in Support of Organizational Policy
(These are some examples)
Acceptable Use
Antivirus
Interconnection


Email Use
Firewall
Host Security
Wireless Use
Extranet
Other Policies
Supporting Mechanisms
Standards
Define specific products and mechanisms used to support policy
Procedures
Define actions to implement policy, standards, and baselines
Baselines
Define minimum required parameters to achieve a consistent
Guidelines
Define recommended (yet not required) actions

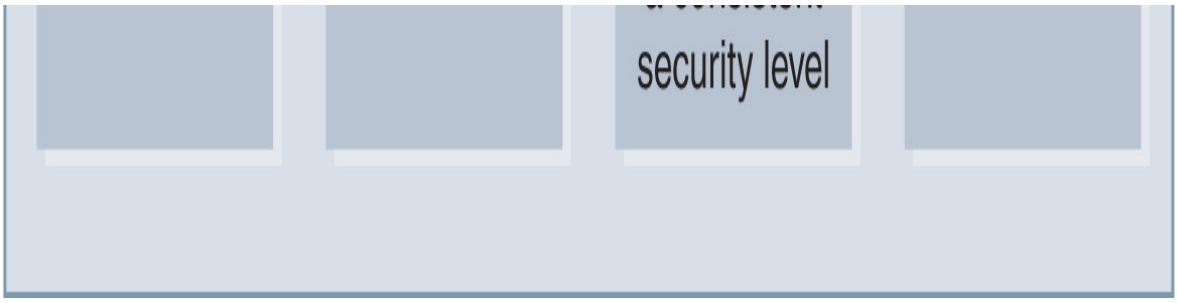


FIGURE 9-2 The security policy hierarchy.

Policies

Written security policies document management's security goals and objectives and explain the company's security needs and its commitment to meeting those needs. A security policy should read like a short summary of key facts because management will have difficulty embracing and approving a policy that is too complex.

For example, a good organizational security policy might read simply as "Security is essential to the future of our organization" or "Security in our products is our most important task." This type of statement provides managers with guidance they need to make decisions. The security policy also helps an organization evaluate how well it is complying with laws, regulations, and standards of due care and due diligence, but the primary purpose of any security-related policy is to reduce risk by helping the organization focus its efforts in a particular area.

Policies that are not read, understood, available, enforced, and updated are not of much value. Post policies in a location available to every employee, for example, in break rooms. Policies must be current, especially in keeping with new laws, regulations, and any other requirements. You should meet with employees at least once a year to ensure they are up to date on the latest policies and be sure to maintain a record of this review with each employee.

A security policy helps all employees understand the assets and principles the organization values. Therefore, with a clear policy, an organization's staff is more likely to respect the organization's resources. Remember, personnel will take policies only as seriously as the organization does.

A **functional policy** sets out the direction for the management of an organization pertaining to security in such specific functional areas as email use, remote access, and Internet interaction (including social media). The departments responsible for these functional policies write them. For example, human resources, IT, operations, and facilities would each produce its own specific functional policy. Moreover, a functional policy should use strong language, such as *will* and *must*, to demand attention, and refrain from using a term such as *should*, which most people consider as merely a suggestion and not a mandate. For example, a clearly stated and strong access control functional policy might read as follows: "All authorized users must be allowed to do *only* their authorized tasks. Unauthorized users must not have access to the company systems or resources."

One example of a functional policy is a **privacy policy**, which specifies to consumers how an organization collects, uses, and disposes of their personal information. Another example of a functional policy is an acceptable use policy (AUP), which sets clear limits on how the organization will allow its assets to be used. The most common focus of an AUP dictates the way personnel must use the organization's computing resources, including guidance on the acceptable use of social media or even specific websites.

Policies allow organizations to state different goals at very high levels. These goals may be intended for their own employees, temporary personnel, business partners, customers, or perhaps all of these groups. They set the organization's tone and communicate commitment in different areas. All decisions that an organization's personnel make should flow from these high-level policies.

Standards

Standards are mandated requirements for hardware and software solutions used to address security risk throughout an organization. Standards might refer to a specific antivirus product or password-generation token. Simply put, when a standard is in place and enforced, it means the organization has selected a solution—and that solution only—to fulfill a policy goal.

Adopting standards carries many advantages. Often, standards save an organization money because it can negotiate bulk purchases with vendors. For example, a vendor might sell a single-user license for $29.95, but that

same vendor might sell multiple licenses for only $24.95 per license. If that organization needs multiple licenses to comply with a standard, bulk purchasing can save the company several thousand dollars. In addition, many vendors offer free training with bulk purchases. Taking advantage of vendor-provided training without cost and using a single solution can save the organization the time and trouble of training its personnel and ensure that everyone follows the same procedures.

You do not have to develop your own standards for each situation because you can adopt standards created by government, industry, or other sectors and use them as the organization's own. Standards also establish a common basis throughout an organization, which helps to keep all departments on the same page and ensures that each department has the blueprints it needs to stay compliant.

The main disadvantage of standards is vulnerability. If the selected product is flawed, the entire organization will be at risk after installing the flawed product. A single standard cannot work if a vendor does not support the product or if it is too expensive to maintain or license. Examine alternatives when evaluating products for standards and be sure that each selection made comes with a guarantee of support if problems arise.

Procedures

One of the most powerful tools available to security professionals is **procedures**, which are step-by-step systematic actions taken to accomplish a security requirement, process, or objective. They can provide documentation of the way an organization does business and ensure that employees' critical knowledge does not remain only in their heads. Procedures cover things such as changing passwords, responding to incidents, and creating backups. **FIGURE 9-3** shows a few examples of procedures.

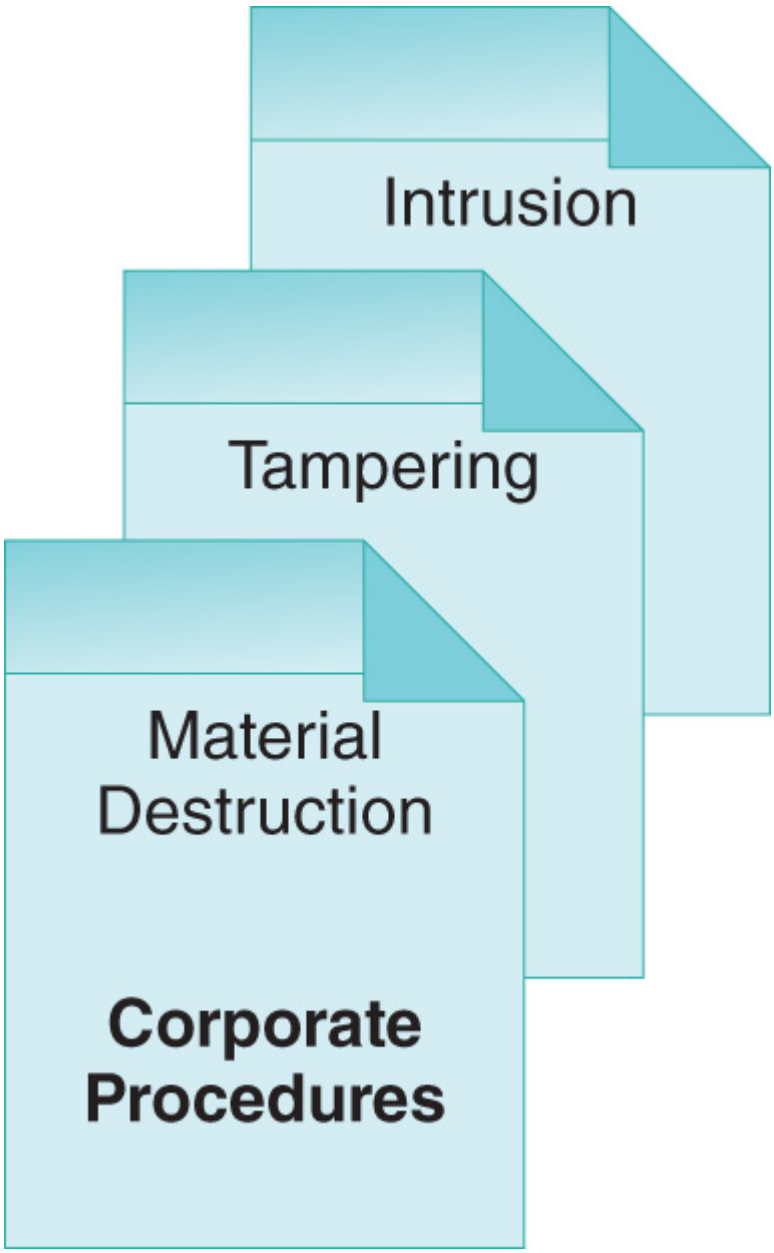


FIGURE 9-3 Systematic actions.

Procedures help enforce the intent of a policy. They require an employee to follow a series of organized steps to complete a task. All of the following statements are true of procedures:

- They reduce mistakes in a crisis.
- They ensure important steps are not missed.
- They provide for places within the process to conduct assurance checks.

- They are mandatory requirements, like policies and standards.

Baselines

In many cases, it is helpful to define and document basic configurations for specific types of computers or devices. For example, having a document that lists the components and configuration settings for a standard workstation makes it easy to ensure that all new workstations are the same. Security personnel often create such basic configuration documents, called **baselines**, to ensure that they enforce the security minimums. Baselines are one type of benchmark that helps ensure a minimum level of security exists across multiple applications of systems and across different products. Baselines are helpful in configuring new computers or devices as well as for comparing with existing systems to see whether they still meet the minimums. **FIGURE 9-4** shows a basic baseline corporate configuration.

FIGURE 9-4 Baseline corporate configuration.

Baselines specify how to implement security devices to make sure that they create a constant level of security throughout the organization. Different systems or platforms have different ways of handling security issues, and baselines tell system administrators how to set up the security hardware devices and software for each platform, which helps achieve and maintain a constant level of security.

Baselines are the great leveler of options offered through different security products, operating systems, and applications, a factor that is becoming increasingly important as more hybrid products enter the security market. These products combine services into multifunctional devices. Organizations often create baseline standards for each operating system in use. There might

be different baselines for Windows 8, Windows 10, Windows Server 2012 R2, Windows Server 2016, Windows Server 2019, macOS, Linux, Android, iOS, and so on.

Guidelines

Organizations often use **guidelines**, which are simply actions that the organization recommends (e.g., which products and systems are acceptable for use), to help provide structure to a security program. These guidelines usually exist in the form of white papers, best practices, or other formats defined by an organization's security program.

You must carefully select the language you use in guidelines. A few wrong words can transform a guideline into a company standard. For example, consider the following example of an overarching statement as dictated by the company CEO: "This company will follow the recommendations of the ISO 27001 standard." That statement makes ISO 27001 mandatory within that organization. Make sure that's the intent before you make such a bold statement.

Data Classification Standards

Mandatory access control (MAC) involves assigning each object a specific classification, which often relies on the regulations that apply to the specific type of data. Examples include the protection of personal information, financial information, and health information.

Classifying data is the duty of the *data owner*, which is the person who owns the data or someone the owner assigns. A similar term, *system owner*, refers to the person or group that manages the infrastructure. System owners are often in control of change or configuration management, but they are *not* in control of data classification.

It's important to understand the difference between clearance and classification. The authorization process grants clearance to *users* (subjects), and the data owner assigns a classification to *data* (objects). Systems enforce access control by determining that a subject has the right clearance to access a classified object and usually enforce access restrictions based on the principles of least privilege and **need to know**.

Organizations consider three criteria in classifying information:

- **Value**—You can define the value of information by several measures: the value to the organization, the value to competitors, the cost of replacement or loss, and the value to the organization's reputation.
- **Sensitivity**—Sensitivity is the measure of the effect that a breach of integrity or the disclosure of information would have on the organization. Organizations can measure sensitivity in many ways, including liability or fines, reputation, credibility, or loss of market share.
- **Criticality**—Criticality is the measure of the importance of the information to the mission of the organization. What would happen to the organization if the information were lost?

Information Classification Objectives

The objectives of classifying information are as follows:

- To identify information protection requirements, which are based on the risk the business faces if the information is disclosed or the data or system is corrupted
- To identify data value in accordance with organization policy
- To ensure that sensitive and/or critical information is provided appropriate protection/controls
- To lower costs by protecting only sensitive information
- To standardize classification labeling throughout the organization
- To alert employees and other authorized personnel to protection requirements
- To comply with privacy laws and regulations

Organizations can derive many benefits from classifying information:

- Data classified as sensitive or critical gets a level of protection that matches that data's classification.
- The organization gets more value for its security investment because it applies increased controls only where it needs them most. Compare, for example, costs of physical security at an expensive jewelry store, an inexpensive jewelry store, and a costume jewelry store. None of those stores would operate efficiently using the security system of any of the others. A costume jewelry store would waste lots of money if it invested the same amount as the store that secures expensive jewelry. Likewise, a store that invests in only minimal security to protect its expensive jewelry exposes itself to excessive risk of loss. All organizations have data that is of high, medium, and low value, and each classification value warrants a different security level.
- Appropriate markings enable staff to recognize the need to protect classified data.

Examples of Classification

The U.S. government uses a hierarchical series of classifications that include Unclassified, Restricted, Confidential, Secret, and Top Secret, all of which are well known and standardized. The private sector (i.e., companies) uses

various categories, such as public (low), private (medium), and confidential (high), which are less well known and not standardized.

These types of categories create issues for the private sector. For example, when employees change jobs, their new employers might value "private" above "confidential," but in their old jobs, their employers valued "private" below "confidential," which makes these classifications confusing. Even more confusing is when this happens within different departments or divisions within the same company. Part of a security professional's job is to identify these inconsistencies and make recommendations to correct them.

NOTE

Compartmentalized information is data that requires special authorization beyond the normal classification system. Therefore, it is important that the procedures include steps to properly handle this type of information.

Classification Procedures

Classification procedures are critical to effective data classification. Thus, before implementing these procedures, it's vital that you first determine their scope and process. Classification *scope* determines what data to classify, whereas classification *process* determines how to handle classified data. You must label and mark all resources properly. Moreover, adhering to strong procedures will ensure that the organization is ready for any upcoming audits.

To determine the scope of a classification plan, you should conduct a business impact analysis to evaluate all of the organization's data. This type of analysis identifies resources, including data, that are important to carrying out critical business functions. Data value is determined according to the following:

- Exclusive possession (trade secrets and intellectual property)
- Utility (usefulness)

- Cost to create or re-create the data
- Liability (protection regulations)
- Convertibility/negotiability (financial information)
- Operational impact (if data is unavailable)
- Threats to the information
- Risks

You initially use the results of the business impact analysis to identify the necessary number of classification levels, the titles of which you will standardize for use throughout the organization. Send this information to the information owners responsible for assigning the initial classifications. These classifiers must understand the related regulations, customer expectations, and business concerns. The goal is to achieve a consistent approach to handling classified information. Therefore, it may be useful to create a training program to instruct the classifiers how to handle all data in a consistent manner.

The owners are also responsible for conducting a periodic review of classifications to ensure they are still current, particularly any time legislators or regulators introduce new government regulations. Finally, the owners are responsible for declassifying information that no longer requires special handling. Government organizations often handle declassification by declaring information automatically declassified after a certain number of years.

You must mark all media containing sensitive information according to the organization's classification policy and procedures, which is the only way personnel will know what special handling measures to use. You should label removable media both electronically and with simple physical labels; documents in hard-copy form require labels externally on the cover and internally on the pages.

Assurance

Internal and external auditors should review the organization's information-classification status as a component of their regular audit process, as well as evaluating the level of compliance with the classification policy and

procedures, to ensure that all parts of the organization adhere to the process. This review might reveal situations in which information is overclassified.

Information security personnel should regularly visit workstations and other areas where users might leave unprotected classified materials. They also should make sure that, when violations occur, they submit appropriate reports to supervisors and managers. Ideally, to help staff understand the importance of handling classified materials, employee performance evaluations should include any instances when employees mishandled information. The organization should consider implementing a clean desk/clear screen policy, which states that users must *never* leave sensitive information in plain view on an unattended desk or workstation.

Configuration Management

One constant you can always depend on in information system environments is change, because it is unusual for any component in a networked computer environment to remain unchanged for a long period. Organizations commonly modify the hardware, software, firmware, documentation, test plans, and test documentation of automated systems throughout the SLC. Because uncontrolled configuration changes often result in conflicts and even new security vulnerabilities, it's important that all configuration changes occur only within a controlled process, which is called *configuration management*.

From the perspective of a security professional, configuration management evaluates the impact a modification might have on security. Will it affect the confidentiality, integrity, or availability of the system, application, or documentation? In this context, the job of the security professional is twofold:

- Be sure to adequately review all system changes before approval or implementation.
- Ensure that the change to the configuration will *not* cause unintended consequences for security; that is, the changes will affect the environment as expected and the environment will operate as authorized.

Hardware Inventory and Configuration Chart

A serious gap in a security program exists when organizations lack a hardware inventory that tells them what they currently have, who has ownership or possession of it, and which departments or systems are using it. In the event of a fire, equipment failure, or theft, this lack of documentation can slow the response and extend operational loss as well as making proper configuration management extremely difficult, if not impossible. A decision to roll out a new patch, service pack, or release will be complicated if you cannot find, update, and test every affected device.

NOTE

One part of an effective configuration management plan is to use standard naming conventions for devices and components. A standard naming convention consists of well-defined labels that indicate a component's function and perhaps even location. Infrastructures that comprise components with standardized names are easier to manage without anyone's having to look up what each component does, and inventory lists are easier to decipher.

Hardware Configuration Chart

Having an up-to-date layout of the configuration of all hardware components is a necessity to help ensure that you configure all systems according to the baseline. It also ensures that you properly review the work completed on a system or network so that you can make the correct changes without bypassing any security features. A hardware configuration chart should include the following:

- An as-built diagram of the network, to help you plan the sequence of a change and see the ripple effects it might generate
- Copies of all software configurations so that you can examine changes and updates planned for one device in terms of their impact on other devices. These configurations should include those for items such as routers, switches, and firewalls. Stored copies of system and device configurations also make it easier to detect unauthorized configuration changes.

Patch and Service Pack Management

It is important to regularly check for any available vendor upgrades and service packs for all hardware and software in the environment, a process that may be quite involved when there are many types of software and hardware from different vendors. Such a process will be impossible, though, if the inventory list is incomplete. To address all known vulnerabilities, the

organization must have a patch-management process to ensure that it rolls out patches to all computers and devices without causing system outages. Therefore, be sure to test every patch before rollout so that that it will not disable other systems or functions.

The Change Management Process

It is common to discuss change and configuration control as a pair of activities, but they are really two ends of a spectrum. The confusion lies in where a particular activity crosses from one to another. Drawing a sharp line between the two is difficult because organizations of different complexities will draw the line in different places:

- **Configuration control** is the management of the baseline settings for a system device so that it meets security requirements. The settings must be implemented carefully and only with prior approval.
- **Change control** is the management of changes to the configuration. Unmanaged changes introduce risk because they might affect security operations or controls, and an improper change could even disable the system or equipment. Change control ensures that any changes to a production system are tested, documented, and approved. The change itself must follow a change control process that ensures that you make the change correctly and report it to management.

Change Control Management

Change control management is a planned approach to controlling change by involving all affected departments. Its objective is to maximize the benefits and minimize the risk of failure for all people involved in the change.

To be effective, change management should be multidisciplinary, touching all aspects of the organization. Nevertheless, an organization should not be so constrained by change management that it loses all flexibility in being able to adopt new technologies, improvements, and modifications.

A written policy approved by the chief information officer or the IT director and the business information security manager is necessary to define all roles, responsibilities, and procedures related to change management. Here are some important things to remember:

- You should communicate change management procedures and standards effectively. They should define the techniques and technologies you will use throughout the enterprise in support of the policy.
- Change management can be either reactive or proactive. Management's responding to external changes in the business environment is reactive change management, examples of which are changes in regulations, customer expectations, and the supply chain. With proactive change management, management initiates the change to achieve a desired goal. In this case, the source of the change is internal, such as the adoption of new technology.
- An organization can conduct change management in several ways: on a continuous basis, a regularly scheduled basis, or a release basis or when deemed necessary on a program-by-program basis.

Reviewing Changes for Potential Security Impact

Change creates risk for a business. It might circumvent established security features, result in outage or system failure, or require extensive retraining for employees to learn how to use the new systems. Because of the risk involved, you must include security personnel in the change control process.

The formal change control process should protect the integrity of the IT systems and ensure that all changes in the production environment are properly tested, scheduled, and communicated. Members of the change control committee attend meetings and forums to estimate, plan, review, and prepare for the organization's production environment.

Change Control Committees

A senior manager or business-process owner should lead a **change control committee**, whose responsibility is to oversee all proposed changes to systems and networks. The committee approves changes and the schedule for implementing the changes. In this manner, you cannot make changes to a system, application, or network without the proper review, funding, and documentation.

In cooperation with IT, the change control committee—in some cases called a *change control board*—provides the oversight to protect the computing resources and the data contained within those applications and

databases. As part of the change process, key members meet with counterparts from the IT organizations to review upcoming plans and ensure that you properly evaluated all changes and the necessary security controls have been applied and evaluated. They then communicate their findings to all parts of the organization.

In brief, the primary objectives of the change control committee are to ensure all changes are as follows:

- Properly tested
- Authorized
- Scheduled
- Communicated
- Documented

Using rigorous change control makes it easy to identify recent changes that might have caused a production problem, which simplifies the problem's root cause and resolution processes and helps make the environment more secure.

Change Control Procedures

Change control procedures ensure that a change does not happen without following the right steps. Following procedures helps you avoid problems such as scope creep, which allows unauthorized changes to sneak into a system, and those caused by lack of oversight, lack of testing, or making changes without proper authorization. **FIGURE 9-5** shows a sequence of change control procedures.

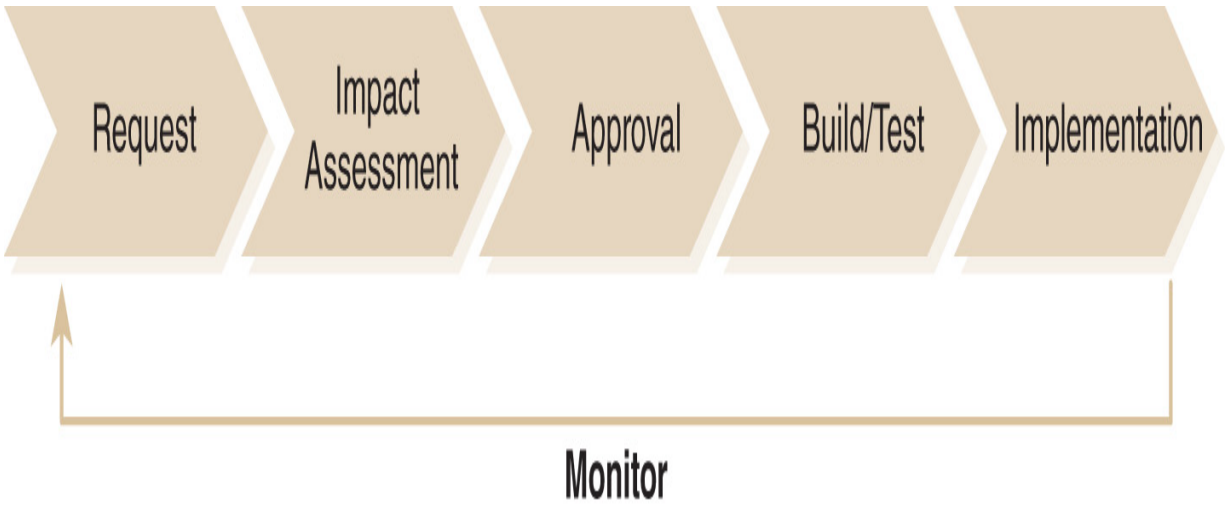


FIGURE 9-5 Change control procedures.

1. **Request**—In the request stage, you should describe all proposed changes in writing and submit the change request to the change control committee for review. You should never make a change to a system without approval.
2. **Impact assessment**—The impact assessment stage evaluates the effect of the change on the budget, resources, and security of the system or project.
3. **Approval**—The approval (or, in some cases, disapproval) stage is the formal review and acceptance (or rejection) of the change by the change control committee.
4. **Build/test**—The build/test stage is the actual development or building of the change according to the approved change document. To ensure that the change does not cause unexpected problems for other systems or components, you must test it, which might include regression testing and an in-depth review of the security of the modified product.
5. **Implement**—Once you test the change and approve it for release, you can schedule the installation process. This is the stage in which adequate separation of duties ensures that no one person can make the change without proper review and oversight. The final hurdle is notifying management that you have made the change successfully.
6. **Monitor**—In this stage, you must monitor all systems to ensure that the system, program, network, and other resources are working correctly.

You should address any user issues or requests using the organization's problem resolution procedures. Monitoring might identify the need for future changes, which then restarts the change control process.

Change Control Issues

Solid change control procedures include the components that tend to identify issues and provide recovery avenues if needed. A successful change control program should include the following elements to ensure the quality of the change control process:

- **Peer review**—This review ensures that a peer or another expert double-checks all changes before you put them into production. Peers can often catch problems before they make it to the testing phase.
- **Back-out plans**—These plans ensure that if the change does not work properly, a process exists to restore the system to a known good condition. Despite the best control procedures, you may accidentally release changes that have unintended effects. Therefore, it is important to know how to undo, or back out of, a destructive change.
- **Documentation**—You must keep documentation current to reflect the system's true design, and you should keep backup copies offsite. Documentation is necessary to understand how the system is supposed to operate.

Application Software Security

One critical area of security concern is application software because secure software can be difficult to design and write and even more difficult to deploy securely. Attackers know that the software development process is complex and that the result of the process is often an application that contains weaknesses, which they can exploit. Therefore, developing and deploying software require attention to security at every stage of the process as well as a structured process to ensure that the software does just what it is supposed to do. To describe and control systems and software development processes, there are several popular methods, two of which are the **system life cycle (SLC)** and the **system development life cycle (SDLC)**. The steps in these processes are very similar except that the SLC includes operations and disposal and the SDLC ends with the transition to production.

For some organizations, maintenance and new development are done by developers, making them part of SDLC. For others, specialized maintenance teams handle maintenance and development, making them part of SLC. More and more organizations use the term *SDLC* to describe the entire change and maintenance process for application and system software.

The System Life Cycle

This section covers the common steps used in the SLC. The more the security professional can be involved in each step, the more likely the system will include the needed security from the start. The main justification for SLC—and for building in security at the start—is to reduce or avoid cost:

- Consumers of commercial software products will see lower costs because you will need to deliver fewer patches and fixes. In addition, there will be fewer losses due to weaknesses in the software that attackers can find and exploit.
- Vendors of commercial software will see lower costs because they require smaller support staffs and have lower warranty and product maintenance costs.

The common steps used in the SLC are as follows:

1. **Project initiation and planning**—One of the first requirements of a successful project is to have all the necessary resources available. The resources required should represent the areas that you need to consider and integrate into the project. Your role is to provide advice on building security into the project from the very beginning, which includes project budgets, system design, maintenance, and the project timeline. You should address threats, vulnerabilities, risks, and controls here first.
2. **Functional requirements and definition**—This is the "what-if?" phase. Always state requirements using positive terms: The program must handle this data or perform that function. You must consider what the program should or will do when the data does not meet the specifications. What happens when the software receives unexpected input? Are there too many characters? Are fields missing? Are users seeing delayed transmissions? Failure to consider these factors creates a great number of security mishaps.
3. **System design specification**—In this phase, a project is broken into functions and modules, which requires that you consider the type of hardware on which the system is going to run. Security issues here include physical security of the hardware and network, as well as accounting for all the possible platforms. It is not enough to say the project is limited to Linux or Windows, for example. Each platform features a wide variety of versions and runs on an almost infinite combination of peripherals, chipsets, and drivers.
4. **Build (develop) and document**—Coding standards should include standard libraries of function calls as well as industry-standard solutions for items such as cryptography, hashing, and access control. You need to secure code in development so that only developers have access and only on a need-to-know basis. You should securely store copies in either printed or machine-readable form, such as on CDs or USB memory sticks, so they are not left lying around.
5. **Acceptance testing**—During the functional design stage, you should create a test plan that must include testing to make sure the new programs provide the necessary security and, where applicable, privacy. Moreover, the people responsible for the tests should not be the

developers, and past-due delivery dates for developers should *not* affect the time allotted for testing.

6. **Implementation (transition to production)**—During this transition, developers will be working on delivery of training and assistance to users and help-desk personnel. Security features need to be carefully explained to both groups. In some organizations, developers also will help manage the turnover of code to maintenance staff.
7. **Operations and maintenance**—When there are problems with the system, it's likely that maintenance, operations, and help-desk personnel will be the first to know. They need to track the issues that come in and be ready to report their results to management. This procedure fuels the change management process. These personnel require training to understand the differences between a request for change, a software malfunction, and a security weakness or breach as well as how to handle each of those events.
8. **Disposal**—Over time, component parts will reach the end of their life span or you will need to upgrade a backup system or procure a larger disk to replace a smaller one. You should ensure that you have procedures to sanitize the media and then dispose of it in a cost-effective way. In years past, organizations would wipe a disk and resell it. Today, the value of a small used disk is often less than the cost to securely wipe it with a tool such as DBAN and then simply dispose of the disk.

Testing Application Software

Security professionals often help test new systems or upgrades to existing systems. These tests should be thorough enough to ensure that you test for all expected and unexpected actions and that you handle errors correctly. You should also perform tests to verify the maximum load on the system, including transaction volume, memory allocation, network bandwidth, and response times. If you use production or sensitive data in testing, make sure you take steps to keep those data secure.

Because input validation attacks are so common, security personnel should work with software testing personnel to make sure tests catch any input vulnerabilities. One type of testing for input vulnerabilities is called *fuzzing*,

which is the practice of providing random input to software to see how it handles unexpected data. Fuzzing can help identify input vulnerabilities better than testers trying to think of bad input.

Systems Procurement

One common way new vulnerabilities make their way into an environment is through a change that causes unintended side effects. Therefore, you should thoroughly evaluate any change to an environment to ensure that it does not introduce new vulnerabilities, and this includes new hardware and software as well. Procuring new equipment is a critical role of the security professional, but doing so can decrease overall security if the process is not handled well. Any time you need to procure new equipment, you should carefully evaluate which products will meet the organization's requirements. To ensure that new equipment does not expose an environment to any new vulnerabilities, you must do the following:

- Evaluate the various solutions that are available
- Evaluate the vendors in terms of maintenance, support, and training
- Use the Common Criteria to ensure that you simplify the evaluation process
- Monitor vendor contracts and SLAs
- Correctly install equipment and formally accept it at the end of the project
- Follow the organization's procurement procedures to ensure a fair purchasing process
- Monitor systems and equipment to identify those that are reaching the end of their life span so that you can schedule them for replacement

The Common Criteria

Because procuring new equipment can lead to security vulnerabilities, formalizing the process makes sense. The need for a formal approach to evaluate systems and equipment gave rise to several sets of standards. The U.S. government created a series of computer security standards documents known as the Rainbow Series, so named because of the bold colors on the covers of the documents. *The Red Book* describes components of a trusted

network infrastructure (TNI), and *The Orange Book* talks about maintaining access control and confidentiality in a classified system. Both books used a series of evaluative levels (C2, B3, and so on), and vendors had their products evaluated against these levels. The developers of the Rainbow Series formally called this classification system TCSEC.

Other governments created their own equivalents by starting with TCSEC and making modifications. Eventually, these systems merged into what became ITSEC. The governments of the United States, the United Kingdom, Canada, Germany, France, and the Netherlands used ITSEC as a starting point, and then they developed a new procurement standard called the Common Criteria.

The Common Criteria include a series of increasingly more difficult evaluation assurance levels (EALs) numbered from 1 (lowest) to 7 (highest). Evaluation labs are scattered worldwide. Leading vendors within an industry (e.g., vendors of firewalls) collectively create a standard, ideal, and perfect solution, and any vendor can have its product evaluated against that standard. An EAL rating assures that the vendor's claims match the collective standard to a defined level of testing and all the product's documentation, development, and performance match the evaluation claims.

Data Policies

All data reaches its end of usefulness at some point, so what do you do when you no longer need or can use data? The answer is to simply follow the guidance in the organization's data policies, which of course means they must already be in place. Policies that cover data management should cover transitions throughout the data's life cycle and contain sections or even full documents that cover retention and storage as well as disposal.

Because data items vary in their lifetimes of usefulness, retention and storage sections of an organization's data policies should state how long to keep different types of data. If you need to keep historical data for research purposes, your policy should address how to store it. Your security policy should extend to cover stored data as well.

But what do you do when you no longer need data? One of two choices exist, either overwrite the data on the media to ready the media for reuse, which is a process called *wiping*, or destroy the media. Your choice depends on the usefulness of the media and the sensitivity of the data. For extremely

sensitive data, the safer choice is to erase the data and destroy the media to keep it out of the hands of someone who may be able to recover all or part of the erased data.

Whenever you need to dispose of equipment, you should ensure that you dispose of it in a secure way so that you do not expose any confidential data. Several options are available to you, including the following:

- **Degaussing**—Applying a strong magnetic force to magnetic media usually makes all electronics unusable.
- **Physical destruction**—Physically destroying the media on which data is stored guarantees that you eliminate any confidential material.
- **Overwriting data**—Even though this option does not destroy the media, it is included here as a viable alternative to actual media destruction. Repeatedly overwriting data on media reduces the chance that any data can be recovered. However, the possibility remains that a determined person may be able to recover some of the overwritten data.

Technical TIP

The formal name for the Common Criteria is ISO/IEC 15408.

Certification and Accreditation

Between procurement and disposal, you will need to ensure that the components in the organization's computing environment are sufficient for your requirements. To do so, both certification and accreditation can be employed. **Certification** is the process of reviewing a system throughout its life cycle to ensure that it meets its specified security requirements, whereas **accreditation** is the formal agreement by the authorizing official to accept the risk of implementing the system. The accreditation process includes the following players:

- **Authorizing official (AO)**—The senior manager who must review the certification report and decide whether to approve the system for

implementation. The AO officially acknowledges and accepts the risk that the system may pose to an agency's mission, assets, or individuals.

- **Certifier**—The individual or team that is responsible for performing the security test and evaluation (ST+E) for the system. The certifier also prepares the report for the AO on the system's operating risk.
- **System owner**—The person responsible for the daily operations of the system and ensuring that the system continues to operate in compliance with the conditions set out by the AO.

Certification.

Certification is the process carried out by a certifier or team of certifiers of technically evaluating a system to provide assurance that the organization implemented the system correctly. The system should meet the initial design requirements to ensure that the security controls are working effectively. The certifier should have the skill to perform the verification process and the tests necessary to prove compliance. Certification of a system means the following:

- The system meets the technical requirements.
- The system meets the functional requirements.
- The system provides assurance of proper operation.

To certify a system, the person (or people) involved in the process must know the technical and functional requirements as well as the capabilities of the system they are recommending for purchase or for approval to move into production. These requirements might be related to either software or hardware. The certifiers might evaluate the systems in terms of quantity or quality, such as the ability to authenticate 100 users a minute or to ensure 99.99 percent uptime, or review non-IT factors, such as weight or energy consumption. The accreditors must examine all the requirements. Whether conducting or managing these tasks, many of them will fall to the security professional.

Finally, the certifiers must assess each requirement to make sure the new system meets or exceeds each specification. When they are sure that it does, they recommend management approval. However, certification of equipment

or software does not mean it is right for the organization or the best solution available. It means only that the product meets its technical and functional specifications and operates as promised.

Accreditation.

Accreditation is the process of management's officially accepting the system after the completion of the certification process. The accreditor or designated approving authority reviews the certification reports and, based on the operational environment, accepts the system for operation. You can define this process in two ways:

- Accreditation is management's formal acceptance of risk.
- Accreditation is management's permission to implement.

Triggers for New Certification.

The certification and accreditation processes ensure that a system not only meets the security requirements today but that it continues to meet them through the operations and maintenance phases of its life cycle. The post-accreditation phase lists the activities required to continue to operate and manage the system so that it maintains an acceptable level of risk. You must continually assess risk to meet this requirement for the following reasons:

- The business must change due to new products, new processes, mergers, or divestitures.
- Products (solutions) that were once accredited might no longer meet the needs of the business.
- Vendors often upgrade or replace products, and these replacements need to be recertified and reaccredited.

Software Development and Security

You learned earlier in this chapter about the importance of developing secure software and that software development requires special attention from a security perspective. Applications represent the most common avenue for users, customers, and attackers to access data, which means you must build the software to enforce the security policy and to ensure compliance with regulations, including the privacy and integrity of both data and system processes. Regardless of the development model an organization adopts, the application must properly perform the following tasks:

- Checks user authentication to the application
- Checks user authorization (privilege level)
- Has procedures for recovering database integrity in the event of system failure
- Handles errors and exceptions consistently with standard responses and does not allow any error or exception to go unhandled because unhandled exceptions can reduce an application's security. Gives consistent error responses and provides clear explanations and instructions to empower users to make the right choices.
- Validates all input (i.e., never accepts any input from a source without validating it first). If the data fails validation, throw it away; do not try to sanitize it. Because attackers can often change data as it travels from a client to a server, validating it on both the client and the server is the only way to be sure that the data is valid. Some attacks that depend on weak validation include the following:
    - **Cross-site scripting (XSS)**—This is an attack in which an attacker inputs client-side script code to a web application. The code would then be viewed by other users, and their client software would execute the script instructions. The XSS attack exploits the trust users have for a server.
    - **Cross-site request forgery (XSRF)**—Similar to the XSS attack, an attacker provides script code that causes a trusted user who

views the input script to send malicious commands to a web server. The XSRF attack exploits the trust a server has in a user.

    - **Structured Query Language (SQL) injection**—This is an attack technique in which an attacker provides malicious SQL statements to access unauthorized data or carry out unauthorized commands.

- Defines secure configuration baselines. When released to end users, the application provides a documented set of configuration settings that define a secure baseline, or starting point.
- Provides guidance on hardening the application. In addition to providing a secure baseline, the application should offer guidance on changing configuration settings that will keep the application secure as well as guidance on further configuration settings or the addition of external controls that will increase the application's security.
- Provides and applies frequent patches. Ensure that you apply the latest security patches for the particular environment. The application should also provide frequent security patches to the users of the application, along with a convenient method of applying patches and managing the patching process.

Software developed in-house will have source code, object code, and runtime executables, all of which you need to manage and protect with policies, standards, and procedures. For example:

- You should protect source code from access by unauthorized users.
- You should track changes to source code by version control systems so that rollback to a previous version is error free.
- Programmers should not be able to update production systems directly (programmers should only be able to promote changes to a test environment, and then another person is required to promote those changes from the test environment to production).

Software Development Models

Secure software development requires a formal model for creating and modifying software. This process is known as the software development life cycle, or SDLC, which uses industry best practices to guide software

development activities as projects with specific start and end dates and a set of required deliverables. At this time, the two most widely accepted models for software development include the following:

- **The waterfall model**—Based on traditional project management practices in which extensive planning precedes any development. Progress through a project moves forward along a well-defined path.
- **Agile development method**—A newer family of project management approaches that depend on very short sprints of activity. Agile works well in very dynamic environments where requirements change and are often revisited.

Technical TIP

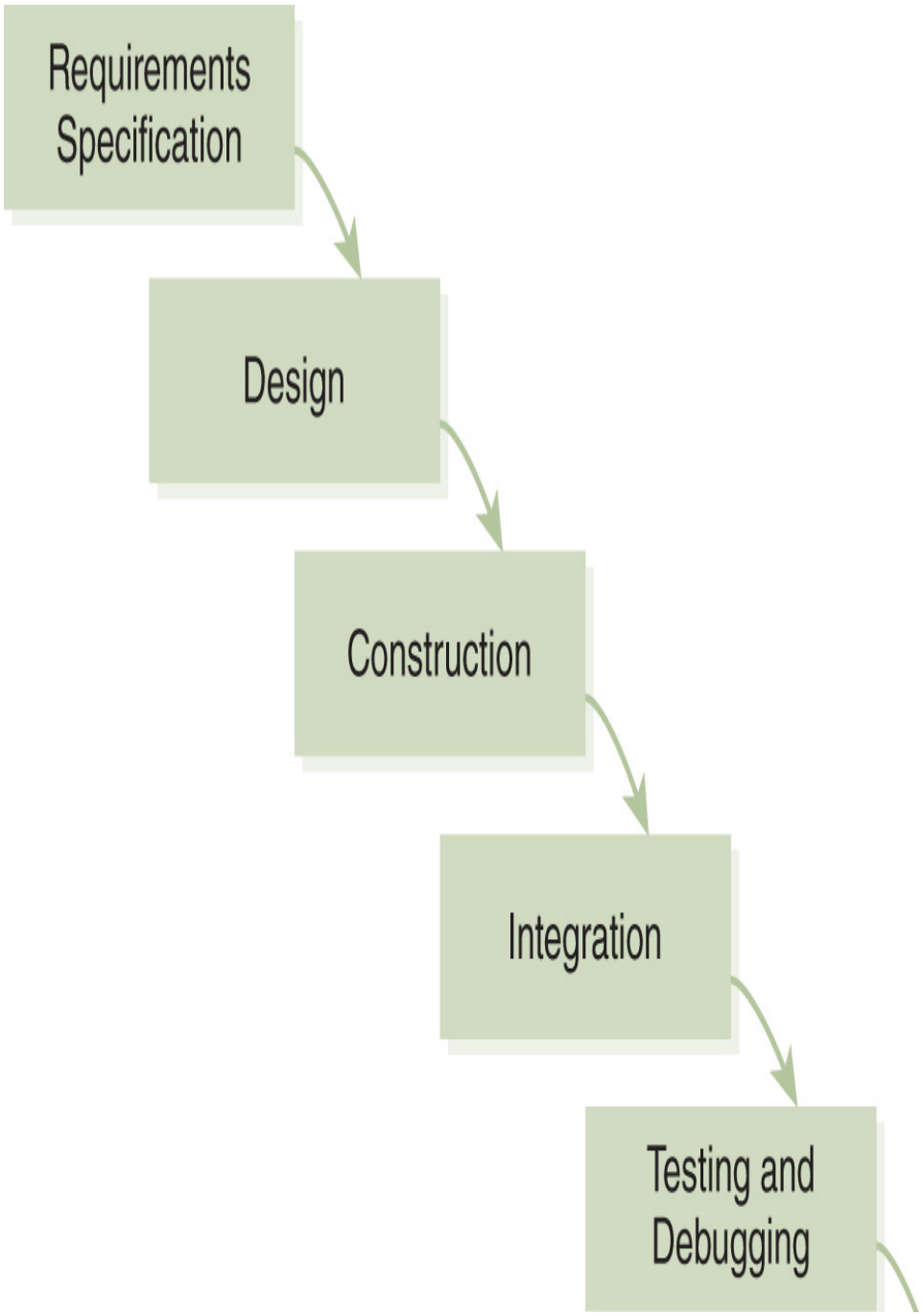
You may recognize SQL injection as a common attack. According to the Open Web Application Security Project (*www.owasp.org*), SQL injection vulnerability is one of the most common recurring vulnerabilities in web applications. Growing databases and a need for faster data have led to a growth in nonrelational databases, called *NoSQL databases*. Although NoSQL databases are not specifically vulnerable to SQL injection attacks, that does not mean you should consider them any more secure than SQL-based databases. Even NoSQL databases are vulnerable to injection attacks.

Waterfall Model

Many current software development methods base their models on the **waterfall model**, which is illustrated in **FIGURE 9-6**. This is a sequential process for developing software and includes the SDLC and the SLC you learned about earlier. In the waterfall model, progress flows downward, like a waterfall. The essence of the waterfall model is that no phase begins until the previous phase has been completed. The phases are as follows:

1. Requirements specification

2. Design
3. Construction
4. Integration
5. Testing and debugging
6. Installation
7. Maintenance



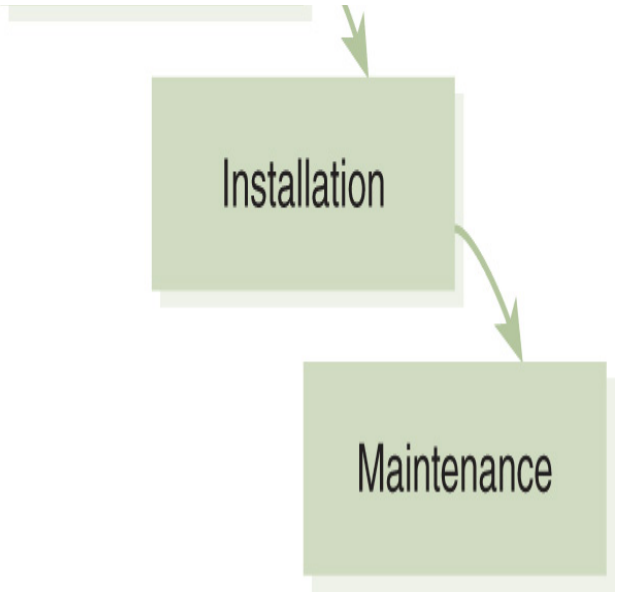


FIGURE 9-6 The waterfall model.

The basic waterfall model originated in the manufacturing and construction industries and is a feature of highly structured physical environments in which late revisions are very costly, if not entirely cost prohibitive. When Winston W. Royce devised this model in 1970, no formal software development methods existed, so he adapted this hardware-oriented model to software development.

Because of perceived shortcomings of the Royce model, you will find modifications of the waterfall model. Most software development models use at least some phases similar to the waterfall model. The importance of the model is in its focus on ensuring that each phase is complete before moving to the next phase. Though this may be quite difficult in large development environments, always invest the time to properly plan and design software. Do not just start writing programs.

Agile Software Development

Traditional software development management is still based largely on some variation of the waterfall method. During the 1990s, some organizations began to realize that the software industry was changing in different ways. Increasing demands to develop more complex software more efficiently led to new methods of managing software development. Instead of managing large projects with long delivery schedules, many organizations looked for

ways to be more responsive, so they chose to develop their software in smaller pieces. This move toward smaller development cycles eventually became known as the **agile development** method.

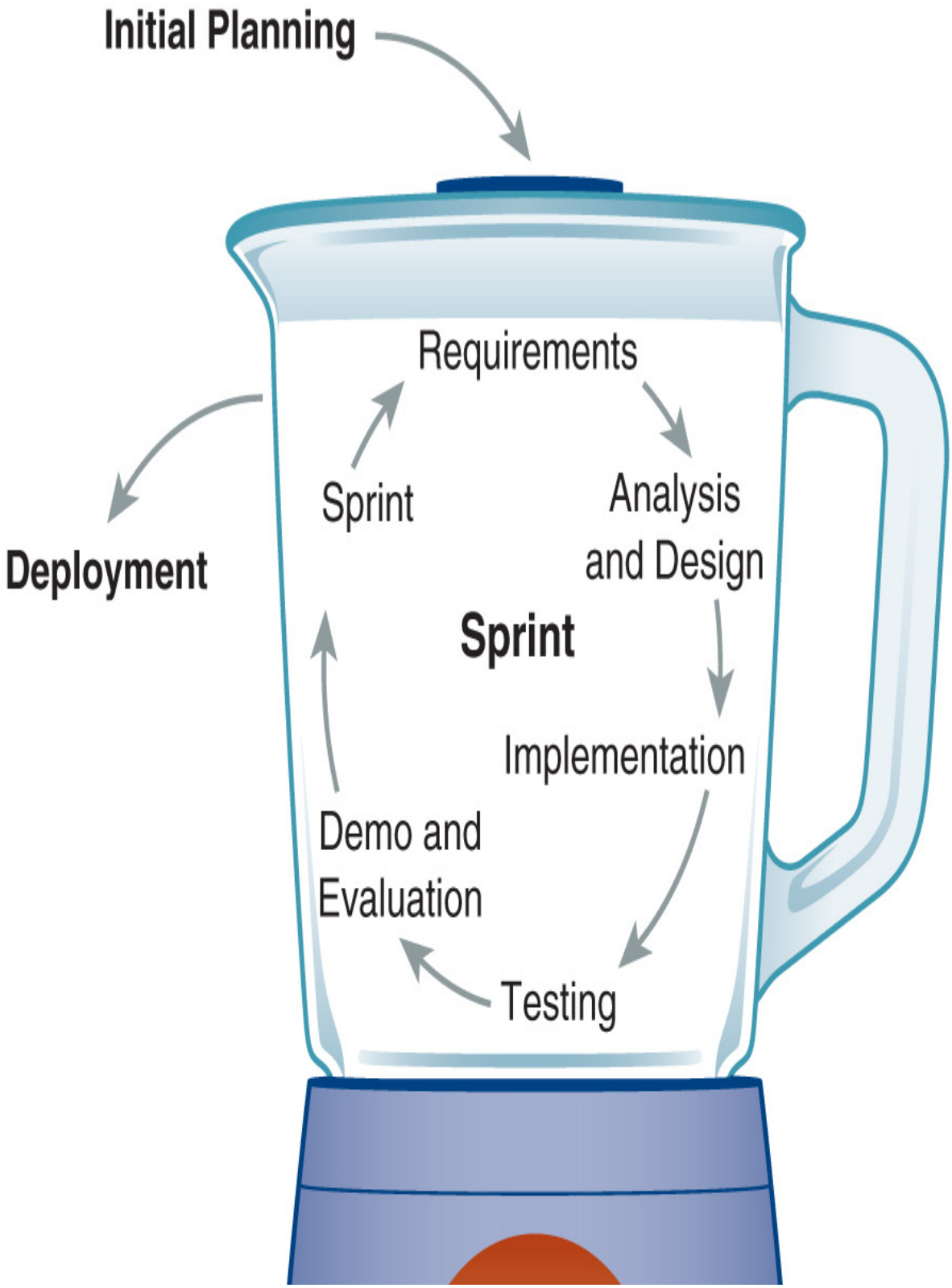
Agile loosely describes a method of developing software that is based on small project iterations, or **sprints**, instead of long project schedules. Organizations that use agile produce smaller deliverables more frequently and can evaluate a large project in terms of its individual pieces as they are completed. Sprints are generally one to four weeks in duration, which means there is some deliverable at least once each month. This focus on frequent delivery makes it possible to see and use pieces of a large software product as it matures over time.

The first organized meeting of agile enthusiasts was in 2001. Several organizations that were exploring this new type of software development sent representatives to a meeting in Snowbird, Utah, to collaborate and exchange ideas. The attendees created the foundational document of the agile movement—the *Manifesto for Agile Software Development*—which is a concise document that reflects its writers' affection for simple methods. Here is the *Manifesto for Agile Software Development* (*https://agilemanifesto.org/*) in its entirety:

> We are uncovering better ways of developing software by doing it and helping others do it. Through this work we have come to value:
>
> - Individuals and interactions over processes and tools
> - Working software over comprehensive documentation
> - Customer collaboration over contract negotiation
> - Responding to change over following a plan
>
> That is, while there is value in the items on the right, we value the items on the left more.

FIGURE 9-7 shows the basic idea behind the agile method. Unlike the waterfall method, agile is designed to be iterative. Each time around the cycle is a single sprint, and many sprints are needed to create a complete software project. Each sprint ends at a specific point in time and should have a deliverable, which should be something such as working software that the

team can demonstrate. The focus on working software helps focus the team on results.



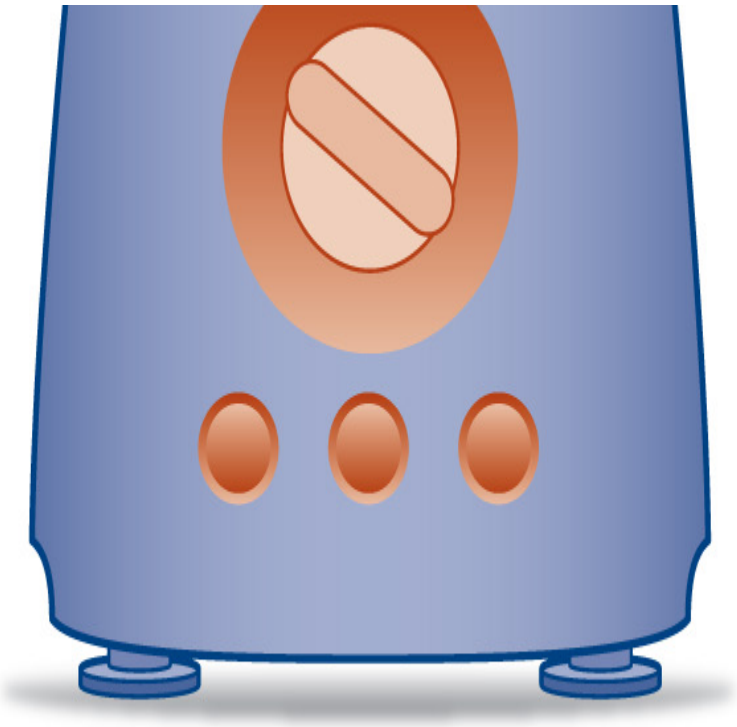


FIGURE 9-7 The agile software development method.

Agile is a popular technique of managing software development projects and tends to perform well in organizations that encourage ongoing communication and value short development cycles. It is important to begin developing software with security in mind from the very beginning. Agile methods encourage developers to plan for security and then test for security at the end of each sprint. Developing secure software can become an integral part of the overall development effort, that is, if the organization values and encourages security. Regardless of the development method an organization uses, attention to security is more important than any method.

NOTE

You can find more information on the *Manifesto for Agile Software Development* and the agile method in general at *https://agilemanifesto.org*. Another good starting point to learn about agile is *www.agilealliance.org/agile101/*.

CHAPTER SUMMARY

In this chapter, you learned that security professionals must understand that security operations and administration are the basis of any solid security program and how security administration works to plan, design, implement, and monitor an organization's security plan. You learned that professional ethics are essential for every solid security plan and what you have to do to make sure a security program is compliant. You learned how the policies, standards, guidelines, and procedures of a plan work together to shape a security program and how data classification standards affect the decision-making process. You learned how to use configuration management to manage system modifications and how configuration control and change control affect the change management process. You explored the eight common steps of the SLC and the SDLC and how these steps reduce costs. Finally, you learned why software development methods require special security considerations and how user awareness is pivotal to the success of a security program.

KEY CONCEPTS AND TERMS

Accreditation
Agile development
Baseline
Certification
Change control
Change control committee
Compliance liaison
Configuration control
Event log
Functional policy
Guideline
Internet Architecture Board (IAB)
Job rotation
Least privilege
Mandatory vacation
Need to know
Privacy policy
Procedure
Remediation
Security administration
Security operations center (SOC)
Separation of duties
Sprint
Standard
System development life cycle (SDLC)
System life cycle (SLC)
Waterfall model

CHAPTER 9 ASSESSMENT

1. Security administration is the group of individuals responsible for planning, designing, implementing, and monitoring an organization's security plan.

   A. True

   B. False

2. The security program requires documentation of:

   A. The security process

   B. The policies, procedures, and guidelines adopted by the organization

   C. The authority of the persons responsible for security

   D. All of the above

   E. None of the above

3. An organization does not have to comply with both regulatory standards and organizational standards.

   A. True

   B. False

4. A(n) _____ is a formal contract between an organization and a third-party external organization that details the specific services the firm will provide.

   A. Security event log

   B. Incident response

   C. Service level agreement (SLA)

   D. Compliance report

5. Which software testing method provides random input to see how software handles unexpected data?

   A. Injection

B. Fuzzing

C. Valid error input

D. Boundary input

6. In 1989, the IAB issued a statement of policy about Internet ethics. This document is known as _____.

A. OECD

B. RFC 1087

C. $(ISC)^2$ Code of Ethics

D. CompTIA Candidate Code of Ethics

E. None of the above

7. _____ is the concept that users should be granted only the levels of permissions they need in order to perform their duties.

A. Mandatory vacations

B. Separation of duties

C. Job rotation

D. Principle of least privilege

E. None of the above

8. Which of the following is an example of social engineering?

A. An emotional appeal for help

B. A phishing attack

C. Intimidation

D. Name-dropping

E. All of the above

9. Policy sets the tone and culture of the organization.

A. True

B. False

10. _____ direct the process of implementing the same hardware and software configurations across an organization to minimize security risk.

A. Policies

B. Standards

C. Procedures

D. Baselines

11. Which of the following is true of procedures?

A. They increase mistakes in a crisis.

B. They provide for places within the process to conduct assurance checks.

C. They result in important steps being overlooked.

D. None of the above

E. All of the above

12. Data classification is the responsibility of the person who owns the data.

A. True

B. False

13. The objectives of classifying information include which of the following?

A. To identify data value in accordance with organization policy

B. To identify information protection requirements

C. To standardize classification labeling throughout the organization

D. To comply with privacy law, regulations, and so on

E. All of the above

14. Configuration management is the management of modifications made to the hardware, software, firmware, documentation, test plans, and test documentation of an automated system throughout the system life cycle.

A. True

B. False

15. The change management process includes _____ control and _____ control.

A. Clearance; classification

B. Document; data

C. Hardware inventory; software development

D. Configuration; change

16. More and more organizations use the term _____ to describe the entire change and maintenance process for applications.

A. System development life cycle (SDLC)

B. System life cycle (SLC)

C. System maintenance life cycle (SMLC)

D. None of the above

17. When developing software, you should ensure the application does which of the following?

A. Has edit checks, range checks, validity checks, and other similar controls

B. Checks user authorization

C. Checks user authentication to the application

D. Has procedures for recovering database integrity in the event of system failure

E. All of the above

18. There are several types of software development methods, but most traditional methods are based on the _____ model.

A. Modification

B. Waterfall

C. Developer

D. Integration

>

CHAPTER 10
Auditing, Testing, and Monitoring

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PLANNING FOR SECURE SYSTEMS does not stop once you've deployed controls. If you really want to protect yourself from system compromises and data breaches, you have to make sure you are ready for any type of attack. To do that, you evaluate your systems regularly, and that includes all hardware, software, communication channels, and the policies and procedures that govern operations and management. To avoid a compromise, a **security audit** is one crucial type of evaluation. When you audit a computing environment, you check to see how its operation has met your security goals. Simply put, you see whether things in the environment work according to plan. Audits also often look at the current configuration of a segment of an environment as a snapshot in time to verify that it complies with requirements.

Auditors can audit a computing environment manually or by using automated software. Manual tests include the following:

- Interviewing the staff
- Performing vulnerability scans
- Reviewing application and operating system access controls
- Analyzing physical access to the environment's components

With automated testing, auditing software creates a report of any changes to important files and settings, both of which might relate to computing devices, operating systems, or application software. Computing devices can include personal computers, mobile devices, autonomous Internet of Things (IoT) devices, servers, network routers, and switches; application software includes any software that runs on any computing device that provides services to users or other devices.

Of course, long before you can audit any part of a computing environment, you need to create the policies and procedures that establish the rules and

requirements of each component. That is, before you can determine whether something has worked, you must first define how it's *supposed* to work, which is a process known as *assessing* the environment. Reviewing all the components of the environment to determine how each component should work sets the baseline expectations. Once all of that is complete, auditing of part or all of the computing environment can begin. You compare the audit results to the baseline expectations to see whether things worked as planned.

Chapter 10 Topics

This chapter covers the following topics and concepts:

- What security auditing and analysis are
- How to define an audit plan
- What auditing benchmarks are
- How to collect audit data
- Which post-audit activities you need to perform
- How to perform security monitoring
- Which types of log information you should capture
- How to verify security controls
- How to monitor and test the security systems

Chapter 10 Goals

When you complete this chapter, you will be able to:

- Describe the practices and principles of security audits
- Review ways to monitor computing environments, including log management and the use of an intrusion detection system (IDS) or intrusion prevention system (IPS)
- Assess an organization's security compliance

Security Auditing and Analysis

The purpose of a security audit is to make sure computing environments and security controls work as expected. When you review your computing environments, you should check for the following:

- **Are security policies sound and appropriate for the business or activity?** The purpose of information security is to support the mission of the business and to protect it from the risks it faces. With respect to security, one of the most visible risks is that of data breach. An organization's policies and supporting documents, which include the organization's procedures, standards, and baselines, define the risks that affect it. The question an auditor seeks to answer is, "Are our policies understood and followed?" The audit itself does not set new policies. Auditors might, however, make recommendations based on experience or knowledge of new regulations or other requirements.
- **Are there controls supporting the policies?** Are the security controls aligned correctly with the organization's strategies and mission? Do the controls support the policies and culture? If you cannot justify a control by a policy, you should consider removing it. For example, whenever a control is explained as "for security," without any further explanation, you should remove it. Security is not a profit center, and it should never exist for its own sake. Rather, it is a support department whose purpose is to protect the organization's assets and revenue stream.
- **Is there effective implementation and upkeep of controls?** As an organization evolves and threats mature, it is important to make sure the controls still meet the risks faced each day.

If you can answer yes to these questions, you're in good shape. If you cannot answer yes, don't worry. You will develop these skills in this chapter.

Security Controls Address Risk

Security controls place limits on activities that might pose a risk to an organization. You must review security regularly to make sure the controls are current and effective. This security review includes the following activities:

- **Monitor**—Review and measure all controls to capture actions and changes to any environment component
- **Audit**—Review the logs and overall environment to provide independent analysis of how well the security policy and controls work
- **Improve**—Include proposals to improve the security program and controls in the audit results. This step applies to the recommended changes as accepted by management.
- **Secure**—Ensure that new and existing controls work together to protect the intended level of security

Although security controls protect computers and networks, you should ensure that each one is necessary and is effective. Each control should protect the organization from a specific threat or collection of threats because a control without at least one identified threat is a layer of overhead that does not make the organization any more secure. It is fine to have multiple controls that address the same threat if each control addresses at least one.

Recall that risk is defined as the probability that a threat will be realized. You can calculate the expected loss by multiplying the risk probability by the asset cost. Identifying risks enables you to measure the validity of the control. When a control costs more than the potential loss if a threat is realized, using that control could be a waste of the organization's resources. One of the best ways to avoid wasting an organization's resources is to follow the security review cycle. **FIGURE 10-1** shows how all the steps in the security review cycle fit together.

FIGURE 10-1 The security review cycle.

Determining What Is Acceptable

The first step toward putting the right security controls in place is to determine what actions are acceptable:

- The organization's security policy should define acceptable and unacceptable actions.

- The organization might create its own standards based on those developed or endorsed by standards bodies.
- Communications and other actions permitted by a policy document are *acceptable*.
- Communications and other actions specifically banned in the security policy are *unacceptable*. Even if the policy does not specifically state it, other communications or actions may be unacceptable as well, such as any action that may reveal confidential information, cause damage to a system's integrity, or make the system unavailable.

Permission Levels

The proper permission level for an organization depends on the organization's needs and its policies. Therefore, it's essential to match the organization's required permission levels with its security structure. Not doing so puts the organization at risk for leaking or losing a lot of data, a situation that, should it happen, could injure the organization's reputation. Users may also simply attempt to bypass the security controls if they are tougher than is necessary. The most common permission levels are as follows:

- **Promiscuous**—Everything is allowed. This permission level is used by many home users, but it makes it easier for attackers to succeed.
- **Permissive**—Anything not specifically prohibited is okay. This permission level is suitable for most public Internet sites, some schools and libraries, and many training centers.
- **Prudent**—A reasonable list of things is permitted, and all others are prohibited. This permission level is suitable for most businesses.
- **Paranoid**—Very few things are permitted, and all others are prohibited and carefully monitored. This permission level is suitable for secure facilities.

Regardless of the levels of permission an organization uses, it is important to "inspect what you expect." This phrase applies to all aspects of auditing and simply means that, if you expect a computer to use prudent permission levels, look closely at its user rights and permissions. Make sure that the controls in

place do what you expect them to do. User rights and permissions reviews are an integral part of any security audit. If you have great security controls in place but you give your users unlimited permissions, you are not keeping your environment very secure.

Areas of Security Audits

On one end of the spectrum, audits can be very large in scope and cover entire departments or business functions, whereas, on the other end of the spectrum, they can be narrow and address only one specific system, device, or control. An audit provides management with an independent assessment of whether the best controls are in place and how well they work, which helps management understand and address risk.

For example, a high-level security policy audit is a review of a security policy to ensure it is up to date, relevant, communicated, and enforced. This type of audit helps ensure that the policy reflects the culture of the organization. They may also help determine whether users or customers accept the controls or try to bypass the ones they view as unrealistic. Moreover, this type of audit tests how well the infrastructure protects the application's data and ensures that the application limits access to authorized users only and hides (encrypts) data that unauthorized users should not see.

An organization should audit all of its firewalls, routers, gateways, wireless access points, IoT devices, and any other network devices to ensure that they function as intended and their configurations comply with the security policy. Audits can also test the technologies themselves by detecting whether all the networked computers and devices are working together according to the policy. They help ensure that the rules and configurations are up to date, documented, and subject to change control procedures.

Purpose of Audits

An audit provides the opportunity to review the risk management program and to confirm that it has correctly identified and reduced (or otherwise addressed) the risks to the organization.

An audit checks controls for the following considerations:

- **Appropriate security level**—Is the level of the security control suitable for the risk it addresses?
- **Correctly installed**—Is the security control in the right place and working well?
- **Effectiveness of purpose**—Is the security control effective in addressing the risk it was designed to address?

The report that auditors create should recommend improvements or changes to the organization's processes, infrastructure, or other controls as needed. Audits are necessary because of potential liability, negligence, and mandatory regulatory compliance and can expose problems and provide assurance of compliance. Many jurisdictions require audits by law.

How Often Should You Conduct Audits?

Audit frequency is an important consideration. Some audits need to be done only on demand, including post-incident audits or any audit required by an external authority, such as a regulatory agency. Other audits should be conducted according to a schedule, such as annually or quarterly, which many regulations require. Internal requirements may call for audits even more frequently. For example, diligent organizations often audit their server logs on a weekly basis and IDS/IPS logs daily. An organization's security policy should include the audit categories and frequency requirements for conducting audits.

Laws and regulations require companies that employ a certain number of employees or are in a particular industry, such as financial services organizations and any organization that handles personal medical records, to have both internal and external audits. Federal laws or vendor standards that require internal and external audits include the Sarbanes-Oxley Act (SOX), the Health Insurance Portability and Accountability Act (HIPAA), and the Payment Card Industry Data Security Standard (PCI DSS). The Personal Information Protection and Electronic Documents Act (PIPEDA) is a Canadian law that protects how organizations collect, use, or disclose

personal information in e-commerce transactions, and the European Union's General Data Protection Regulation (GDPR) is a regulation that protects personal data and individual privacy. Both PIPEDA and GDPR include audit requirements.

On one hand, an audit might find that an organization lacks sufficiently trained and skilled staff and show that the company does not do enough to oversee security programs and manage assets. On the other hand, an audit might validate that an organization is meeting or even exceeding its requirements.

Many new regulations make management personally responsible for fraud or mismanagement of corporate assets. In the past, corporations were mostly accountable for these failings, but, now, individuals are responsible. It is in the organization's best interests to make every effort to be compliant with all necessary requirements to protect itself and its people.

Customer Confidence

Customers will generally conduct business only with organizations they trust. Therefore, if customers know that an organization's systems are consistently audited for security, they may be more willing to share their sensitive information with that organization.

Many business-to-business service providers use auditing standards to build customer confidence. The Auditing Standards Board of the American Institute of Certified Public Accountants issued the Statement on Auditing Standards Number 70 (SAS 70) in 1993. This was the first standard of its kind and provided audit guidance for many service organizations. SAS 70 was developed for organizations such as insurance and medical claims processors, telecommunication service providers, managed services providers, and credit card transaction processing companies. There were two types of SAS 70 audits: Type I and Type II. An SAS 70 Type I audit encompassed the service auditor's assessment of the service organization's description and implementation of controls to achieve the environmental control objectives. An SAS 70 Type II audit included the information in a Type I audit as well as the service auditor's assessment of whether the identified controls were implemented and operating effectively. Although SAS 70 was general in its scope, the standard did not address many of the

emerging issues encountered in today's service organizations. For example, SAS 70 did not address supporting co-location or providing cloud-based services. Therefore, SAS 70 was officially retired in June 2011.

In 2011, the Statement on Standards for Attestation Engagements Number 16 (SSAE 16) superseded SAS 70, and in 2017, SSAE 18 superseded SSAE 16. SSAE 16 expanded the scope of SAS 70 and was the predominant auditing and reporting standard for service organizations, and SSAE 18 further clarified the standard's scope by providing guidance to auditors when verifying controls and processes. It also requires that the reports include descriptions of the design and effectiveness of the audited controls. These reports provide details that describe the organization's specific controls. For example, a company seeking to lease space in a data center might ask the data center to provide the results of an SSAE 18 audit to get an independent assessment of the security controls in that data center.

Reliance on the results of SAS 70, and now SSAE 18, has increased across many organizations. The AICPA has recognized the increased complexities of service organizations and created three levels of audit reporting for service organizations. The **Service Organization Control (SOC)** framework defines the scope and contents of three levels of audit reports. **TABLE 10-1** lists the SOC reports and characteristics of each one.

TABLE 10-1 Service Organization Control (SOC) reports.

REPORT TYPE	CONTENTS	AUDIENCE
SOC 1	Internal controls over financial reporting	Users and auditors. This is commonly implemented for organizations that must comply with Sarbanes-Oxley (SOX) or the Gramm-Leach-Bliley Act (GLBA).
SOC 2	Security (confidentiality, integrity, availability) and privacy controls	Management, regulators, stakeholders. This is commonly implemented for service providers, hosted data centers, and managed cloud computing providers.

REPORT TYPE	CONTENTS	AUDIENCE
SOC 3	Security (confidentiality, integrity, availability) and privacy controls	Public. This is commonly required for the customers of SOC 2 service providers to verify and validate that the organization is satisfying customer private data and compliance law requirements (such as HIPAA and GLBA).

SOC 1, SOC 2, and SOC 3 reports are important tools for an organization's auditors. The SOC 1 report primarily focuses on internal controls over financial reporting (ICFR). This type of report is often used to prepare financial statements for the user organization and to implement proper controls to ensure the confidentiality, integrity, and availability of the data generated by the financial reporting requirements. Both SOC 2 and SOC 3 reports address primarily security-related controls that are critical to the success of today's technology service provider organizations. The primary difference between SOC 2 and SOC 3 reports is their audience. SOC 2 reports are created for internal and other authorized stakeholders, whereas SOC 3 reports are intended for public consumption.

NOTE

For more information about SAS 70, see *http://sas70.com*; for more information about SSAE 18, see *https://ssae-18.org/*; and for more information on SOC 1, SOC 2, and SOC 3 reports, see *https://ssae-18.org/soc-reports/*.

Defining the Audit Plan

In planning the activities for an audit, auditors must first define the objectives and determine which systems or business processes to review as well as defining which areas of assurance to check.

They must also identify the personnel—both from their own team and from the organization being audited—who will participate in the audit. These people will gather and put together information to move the audit along. Auditors must be sure that everyone has the right skills, is prepared to contribute, and is available when needed.

Some auditors include a review of previous audits to become familiar with past issues, whereas others choose not to review previous audits to avoid being prejudiced by prior conclusions.

Defining the Scope of the Plan

You must define the boundaries of the review at the beginning of the project to determine which areas the audit will review and which it will not. You must be sure that the areas not reviewed in the current audit will be subject to another audit, and you must designate responsibility for those areas. All systems, devices, and networks must have a clearly designated owner. In some cases, the scope of an audit may need to extend beyond a single organization; for example, when an organization outsources data or processing, you may need to include assets that exist outside the organization. If you use managed security service providers (MSSPs), you will need to coordinate any audit activity with the service provider. You may need to audit components that you access through an interoperability agreement, and determining the scope of an audit may require interaction with external organizations.

At this point, you need to decide whom to inform that an audit is underway. In many cases, if users know you are auditing them, they may start to follow rules they had previously ignored, thereby changing their behavior and decreasing the accuracy of the audit. On the other hand, trying to perform an audit without telling staff makes the job more difficult by limiting access to

critical information. You have to consider this trade-off on a case-by-case basis. **FIGURE 10-2** shows how the scope of an audit can span all seven domains in the information technology (IT) infrastructure.

NOTE

Auditing every part of an organization and extending into all outsourcing partners may not be possible because of resource constraints. Auditors should give the highest-risk areas the top priority.

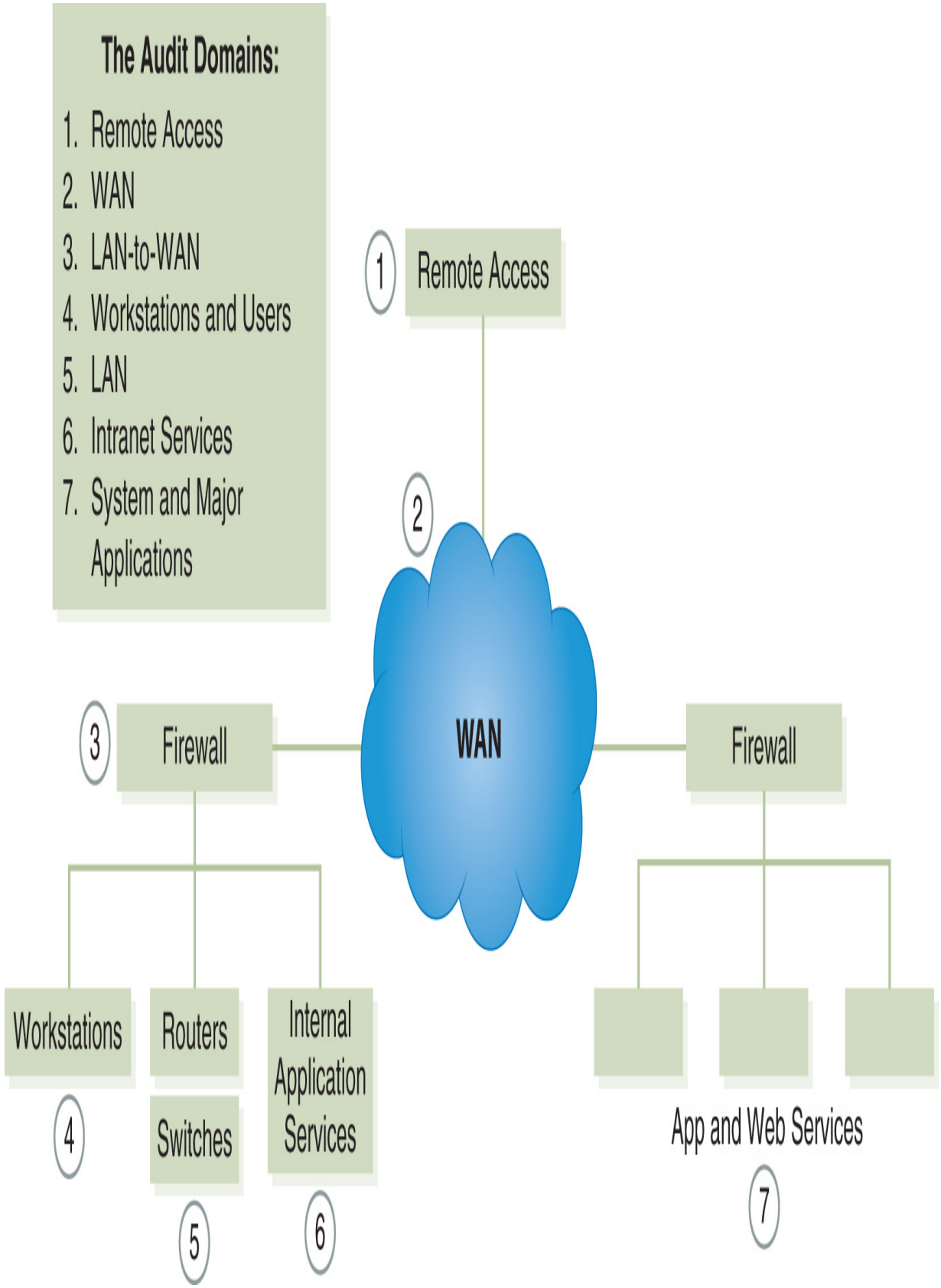

The Audit Domains:
1. Remote Access
2. WAN
3. LAN-to-WAN
4. Workstations and Users
5. LAN
6. Intranet Services
7. System and Major Applications
1
Remote Access
2
WAN
3
Firewall
Firewall
Workstations
4
Routers
Switches
5
Internal Application Services
6
App and Web Services
7

FIGURE 10-2 Audit scope and the seven domains of the IT infrastructure.

Auditors should take the time to properly plan an audit before conducting any audit activities. Planning is far more than just listing the files and documents to inspect. In fact, auditors often do a substantial amount of work preparing for an audit. Here's what you can expect from auditors throughout the planning and execution phases:

- **Survey the site(s)**—Auditors will want to understand the complete environment and the interconnections between systems and devices before starting any active audit activities.
- **Review documentation**—Auditors will review system documentation and configurations, both during planning and as part of the actual audit. Reviewing interoperability agreement requirements is necessary when audits include external partners. These documents specify agreed-upon compliance requirements for outsourcing partners.
- **Review risk analysis output**—Auditors will want to understand system criticality ratings that are a product of risk analysis studies. Having this information helps them rank systems into the appropriate order for mitigation in the reporting phase.
- **Review server, device, and application logs**—Auditors might ask to examine logs to look for changes to programs, permissions, or configurations.
- **Review incident logs**—Auditors might ask to review security incident logs to get a feel for problem trends.
- **Review results of penetration tests**—When an organization conducts penetration tests, the tester prepares a report listing weaknesses that were found. Auditors need to review this report and make sure that the audit addresses all items.

Auditing Benchmarks

A **benchmark** is the standard collection of configuration settings or performance metrics to which a system is compared to determine whether it is securely configured. One technique in an audit is to compare the current setting of a computer or device with a benchmark to help identify differences.

In this section, you will find common ways to audit or review systems, devices, business processes, or security controls. All of these examples are best practices and often are used as guidelines for auditing a business or business process. An organization's management may have formally adopted one of the following examples, which can be especially true if the organization is subject to government regulation or legislation. If so, then the benchmark directs the main course of an audit. Otherwise, auditors, with senior management's approval, decide how an audit is carried out.

- **ISO 27002**—ISO 27002 is a best-practices document that gives guidelines for information security management. For an organization to claim compliance, it must perform an audit to verify that all provisions are satisfied. ISO 27002 is part of a growing suite of standards, the ISO 27000 series, that defines information security standards.
- **National Institute of Standards and Technology (NIST) Cybersecurity Framework (CSF)**—First released in 2014, NIST CSF is a response to a U.S. Presidential Executive Order calling for increased cybersecurity. It focuses on critical infrastructure components but is applicable to many general systems. The road map provides a structured method to securing systems that can help auditors align business drivers and security requirements. NIST updated the CSF to version 1.1 in 2018 and also publishes a series of special publications that cover many aspects of information systems. For example, NIST SP 800-37 is a standard that describes best practices, including auditing, for U.S. government information systems.
- **Information Technology Infrastructure Library (ITIL)**—This is a set of concepts and policies for managing IT infrastructure, development, and operations. ITIL is published in a series of books, each covering a

separate IT management topic and giving a detailed description of a number of important IT practices, with comprehensive checklists, tasks, and procedures that any IT organization can tailor to its needs.

Other organizations, such as the Information Systems Audit and Control Association (ISACA) and the Institute of Internal Auditors (IIA), have developed commonly used audit frameworks. An organization might develop a set of guidelines in-house or adopt and customize an audit framework developed elsewhere. Here are two examples of these types of frameworks:

- **COBIT**—The Control Objectives for Information and Related Technologies (COBIT) is a set of best practices for IT management. It was created by the Information Systems Audit (ISA), ISACA, and the IT Governance Institute (ITGI) in 1996. COBIT gives managers, auditors, and IT users a set of generally accepted measures, indicators, processes, and best practices. You can use COBIT to help obtain the most benefit from the use of IT and to develop appropriate IT governance and control in a company.
- **COSO**—The IIA produces the Committee of Sponsoring Organizations (COSO) of the Treadway Commission. This volunteer-run organization gives guidance to executive management and governance entities on critical aspects of organizational governance, business ethics, internal control, enterprise risk management, fraud, and financial reporting. COSO has established a common internal control model, which many companies and other organizations use to assess their control systems.

NOTE

NIST SP 800 is a series of best-practices documents. NIST's website, *https://csrc.nist.gov/publications/final-pubs*, is organized with the newest documents listed first. Lower-numbered items might still be current because revisions do not change the number.

Unless a law or regulation prohibits it, organizations are free to choose whatever audit methods make the most sense to them. They might use one of the options mentioned here or guidelines from another organization or trade group or even develop their own document. Whichever method fits your requirements best, ensure you have an audit method to follow before conducting your first audit.

Audit Data Collection Methods

Before you can analyze data, you need to identify what you need and then collect it. There are many ways to collect data, including the following:

- **Questionnaires**—You can administer prepared questionnaires to both managers and users.
- **Interviews**—Interviews are useful for gathering insight into operations from all parties. They often prove to be valuable sources of information and recommendations.
- **Observation**—Observation refers to input used to differentiate between paper procedures and the way the job is really done.
- **Checklists**—Checklists are prepared documents that help ensure that the information-gathering process covers all areas.
- **Reviewing documentation**—Reviewing documentation assesses currency, adherence, and completeness.
- **Reviewing configurations**—Reviewing configurations involves assessing change control procedures and the appropriateness of controls, rules, and layout.
- **Reviewing policy**—Reviewing policy involves assessing policy relevance, currency, and completeness.
- **Performing security testing**—Performing security testing includes **vulnerability testing** and **penetration testing** and involves gathering technical information to determine whether vulnerabilities exist in the security components, networks, or applications.

Areas of Security Audits

Part of the auditing process is to ensure that policy statements exist for all key areas. Auditors document any key areas that a policy does not address or does not address sufficiently. Next, they check to see whether all personnel are following the policies, procedures, and standards.

Both a password standard (i.e., minimum characters and complexity) and a password procedure (i.e., guidelines for setting, changing, and resetting passwords) are necessary to support the access control policy. Many organizations use their password policies as their system access policies, but this is a dangerous mistake. You should develop a separate access control policy that says something similar to the following:

> Authorized users should be able to carry out only functions they are authorized to carry out. Unauthorized users should be prohibited from accessing any resources or carrying out any functions.

NOTE

The audit process should be a cooperative arrangement in which all parties work together to make an organization more secure. You should not view it as "us versus them." Both the auditors and the audited organization should be working toward the same goal: a more secure environment.

Because passwords are so often the targets of attacks, the use of passwords as the only authentication method is declining. Instead, many organizations are starting to use tokens, smart cards, or biometrics for authentication. (Of course, a combination of these authentication types is even better.) As an IT environment changes, make sure your policies change, too. You do not want all the access control policies to dictate password strength when half your systems are using smart cards. A thorough audit ensures that the security policy is up to date and reflects the current environment. You should identify and remove any policies that are out of date.

TABLE 10-2 shows several of the critical areas that you should include in a security audit.

TABLE 10-2 Areas that you should include in an audit plan.

AREA	AUDIT GOAL
Endpoint protection (antivirus/anti-malware, endpoint detection and response [EDR], host-based firewall)	Up-to-date, universal application
System access policies	Current with technology
Intrusion detection and event-monitoring systems	Log reviews
System-hardening policies	Ports, services
Cryptographic controls	Key management, usage (network encryption of sensitive data)
Contingency planning	Business continuity plan (BCP), disaster recovery plan (DRP), and continuity of operations plan (COOP)
Hardware and software maintenance	Maintenance agreements, servicing, forecasting of future needs
Physical security	Doors locked, power supplies monitored
Access control	Need to know, least privilege
Change control processes for configuration management	Documented, no unauthorized changes
Media protection	Age of media, labeling, storage, transportation

Control Checks and Identity Management

It is important to ensure that the security controls are effective, reliable, and functioning as required and expected. Without monitoring and reviewing, you have no assurance that the information security program is effective or that personnel are exercising due diligence. When auditing an identity management system, these key areas should be the focus:

- **Approval process**—Who grants approval for access requests?
- **Authentication mechanisms**—What mechanisms are used for specific security requirements?
- **Password policy and enforcement**—Does the organization have an effective password policy and is it uniformly enforced?
- **Monitoring**—Does the organization have sufficient monitoring systems to detect unauthorized access?

- **Remote access systems**—Are all systems properly secured with strong authentication?

NOTE

Auditors routinely interact with management during the audit to qualify and validate what they are finding. Auditors are capable of making mistakes, and this gives management the chance to correct misunderstandings and state their case before the auditors issue their final report.

Post-Audit Activities

After completing the audit activities, the auditors still have more work to do. Such tasks include exit interviews, data analysis, generation of the audit report, and a presentation of findings to management.

Exit Interview

Auditors perform an exit interview with key personnel to alert them to major issues and recommendations that will come later in the audit report. This enables management to respond quickly and act on serious issues. Aside from these early alerts, auditors should not provide details before the final report. If they do, they might give a false view of the organization's security preparedness.

5.2 Data Analysis

Auditors commonly analyze data they collect away from the organizational site, when such data removal is permitted. This enables auditors to review everything learned and to present observations using a standard reporting format. Offsite analysis also enables auditors to remove themselves from the pressure often encountered while onsite. Every organization wants to receive a positive audit report, and that desire sometimes translates into subtle pressure on auditors. Thus, performing data analysis at a different location from the audited organization can help encourage unbiased analysis.

Generation of Audit Report

Audit reports generally contain at least three broad sections:

- **Findings**—The findings are often listed by level of compliance to the standard benchmark. The comparison of audit findings with a stated policy or with industry best practices gives a picture of where the organization must improve.

- **Recommendations**—Auditors recommend how to fix the risks they have found as well as tell how the staff might not be complying with a policy or process. In most reports, the recommendations address the most important issues first. Audit recommendations should include the following:
    - **Timeline for implementation**—Change recommendations should not be open ended. Each recommendation should have a suggested deadline.
    - **Level of risk**—The audit should make clear the level of risk the organization faces from each finding.
    - **Management response**—Auditors should give management an opportunity to respond to a draft copy of the audit report and then put that response in the final report. This response often clarifies issues and explains why controls were not used or recommendations in the draft copy are not necessary. The response can also include action plans for fixing gaps in controls.
- **Follow-up**—When necessary, auditors should schedule a follow-up audit to ensure the organization has carried out recommendations.

NOTE

An effective audit report gets right to the point and often begins with a summary followed by the details. Because the summary may find its way outside the organization's leadership, auditors should take care not to expose security weaknesses in it. Be sure that private or confidential information appears only in the details section of the report, and always label such information appropriately.

Presentation of Findings

When the auditors complete the audit report, they present their findings to the organization. Depending on the organization's structure and size, the findings presentation could be a formal meeting, or it could simply involve delivering

the report to a single person. Regardless of how the audit findings are received, it is important that the audited organization examine the report and make the necessary changes. The findings might lead to changes based on regulatory requirements or available budget.

Security Monitoring

The first goal of a security program is to set the security posture of an organization. The security policy defines the security posture, but the security program carries out the policy in actions. A security posture specifies how an organization documents initial configurations, monitors activity, and remediates any detected issues. Monitoring is an important part of any security program, and its primary purpose is to detect abnormal behavior. After all, you cannot remediate behavior that you do not detect. Security monitoring systems might be technical in nature, such as an IDS, or they might be administrative, for example, observing employee or customer behavior on a closed-circuit TV.

When you detect abnormal or unacceptable behavior, the next step is to stop it. Stopping overt and covert intrusive acts is both an art and a science. **Overt acts** are obvious and intentional, whereas **covert acts** are hidden and secret.

Many attackers will attempt to avoid detection controls that are in place. On one hand, just the presence of security-monitoring controls can deter most casual attackers, whereas, on the other hand, it is possible to have too many monitoring devices. Security monitoring must be obvious enough to discourage security breaches but adequately hidden so as not to be overbearing.

Some tools and techniques for security monitoring include the following:

- **Baselines**—Baselines are essential in security monitoring. But to recognize something as abnormal, you first must know what normal looks like. Seeing a report that says a system's disk space is 80 percent full tells you nothing unless you know how much disk space was used yesterday or even last week. That is, a system that used an additional 1 percent of disk every week and just tipped the alarm is very different from a system that was at 40 percent for the last month but suddenly doubled in usage.
- **Alarms, alerts, and trends**—Reporting detected security events is necessary to maintain secure information systems. Alarms and alerts are

responses to security events that notify personnel of a possible security incident, much like a door-open alert or a fire alarm, and the difference between an alarm and an alert depends on the asset state. Opening a door generates an alert if an alarm is not set. However, once an alarm is set, opening the door generates an alarm. This works like your home alarm system. During the day, opening a door may just cause the system to create a tone (alert), but at night, opening the door triggers an alarm. Be aware that employees will quickly ignore repeated false alarms. For example, if your neighbor's car alarm goes off repeatedly, you do not run to the window each time. That means employees will likely not respond to a real incident. For this reason, storing alerts and alarms makes it possible to show how events occur over time. This type of analysis helps identify trends, which helps auditors focus on more than just individual events.

- **Closed-circuit TV**—Properly using a closed-circuit TV involves monitoring and recording what the TV cameras see. You must ensure that the security officers monitoring the cameras are trained to watch for certain actions or behaviors. Security staff must also be trained in local law. For example, many jurisdictions prohibit profiling based on race or ethnicity and require that policies and procedures align with legal monitoring practices.
- **Systems that spot irregular behavior**—Examples include IDSs and honeypots, which are traps set to capture information about improper activity on a network.

Security Monitoring for Computer Systems

Just as there are many types of physical monitoring controls, there are also many ways to monitor computer, device, and network system activity. You must select the controls that monitor the many aspects of the computing environment to detect malicious activity. Many tools exist to help you monitor the system's activities, both as they are occurring and after the fact.

Real-time monitoring provides information on what is happening as it happens. This type of monitoring is important in maintaining a proactive security posture. You can use the information from real-time monitoring controls to contain incidents and preserve an organization's business

operations. A network IDS is one example of a real-time monitoring control. It monitors and captures network traffic as it travels throughout the network. Examples of this type of control include the following:

- **Host-based IDS**—A host-based IDS (HIDS) is excellent for "noticing" activity in a computer as the activity is happening. IDS rules help identify suspicious activity in near real time.
- **System integrity monitoring**—Systems such as Tripwire enable you to watch computer systems for unauthorized changes and report them to administrators in near real time.
- **Data loss prevention (DLP)**—DLP systems use business rules to classify sensitive information to prevent unauthorized end users from sharing it. Data that DLP protects is generally data that could put an organization at risk if it were disclosed. For example, DLP systems prevent users from using external storage services, such as Dropbox, for sensitive data.

Non–real-time monitoring keeps historical records of activity. You can use this type of monitoring when detecting and immediately responding to incidents is less critical. Examples of this type of control include the following:

- **Application logging**—All applications that access or modify sensitive data should have logs that record who used or changed the data and when. These logs support proof of compliance with privacy regulations, investigation of errors or problems with records, and tracking of transactions.
- **System logging**—This type of logging provides records of who accessed the system and what actions they performed on the system.

Following is a partial list of activities that you need to log:

- **Host-based activity**—This activity includes changes to systems, access requests, performance, and startups and shutdowns.
- **Network and network devices**—These activities include access, traffic type and patterns, malware, and performance.

Monitoring Issues

Logging does have its costs because, any time you choose to log system or application activity, you have to store that information somewhere. Many organizations turn off logs because they produce too much information. After all, without enough staff to review the logs, what's the point of gathering lots of data? Without a way to automatically analyze log data, logging simply uses up disk space, without providing much value. Other challenges include the poor quality of the log data and the complexity of attacks. Often, it's difficult to see the value in eating up staff time to analyze logs.

NOTE

Organizations should monitor traffic to ensure that all sensitive data is encrypted as the data is transmitted through the network.

Other monitoring issues that scare off some organizations from aggressive monitoring include the following:

- **Spatial distribution**—Attacks are difficult to catch with logs if they come from a variety of attackers across a wide area. To make matters worse, attackers can use a number of computers managed by different administrators and spread over a large area.
- **Switched networks**—It can be harder to capture traffic on networks that are very segmented using switches and virtual local area networks (VLANs). It will take more work to reconstruct what happened from segmented log files.
- **Encryption**—Encrypting data makes logging more difficult because monitors cannot see all the data to decide whether it is suspicious. Unencrypted parts can be logged, but the rest is virtually invisible. You can encrypt data at various levels:
    - **Data Link Layer encryption (wireless Wired Equivalent Privacy [WEP] and Wi-Fi Protected Access [WPA])**. With this

type of encryption, you encrypt everything above the Data Link Layer. Because of its well-known weaknesses, you should never use WEP encryption for wireless security; instead, use WPA2 or WPA3.

- **Network Layer encryption (Internet Protocol Security [IPsec] and some other tunneling protocols)**. With this type of encryption, you encrypt everything above the Network Layer.
- **Application Layer encryption (Secure Sockets Layer/Transport Layer Security [SSL/TLS] and Secure Shell [SSH] and others)**. This type of encryption encrypts above the Transport Layer.

Logging Anomalies

One important aspect of monitoring is determining the difference between real attacks in log entries and activity that is merely noise or minor events. In doing this, monitors of all types make two basic types of mistakes:

- **False positives**—Also known as Type I errors, **false positives** are alerts that seem malicious yet are not real security events. These false alarms are distractions that waste administrative effort, and over time too many of them can cause the administrator to ignore real attacks. To combat this, you might decide not to record infrequent or human-error "attacks." You can do this by creating **clipping levels**, which ignore an event unless it happens often or meets some other predefined criteria. For example, a failed logon attempt should not be of much interest unless it occurs several times in a short period. A common clipping level for failed logons is five, which means the system will trigger an alarm any time a user logon fails five times in a row. Clipping levels help reduce the number of false-positive errors.
- **False negatives**—The other type of monitoring error is a failure of the control to catch suspicious behavior, or a **false negative** (also called a Type II error). False negatives result from the failure of an alarm system to detect a serious event. Perhaps the event went unnoticed, or maybe the alarm was fooled into thinking the event was not serious when in fact it was. In some monitoring controls, false negatives are a result of

the control's being configured incorrectly. Thus, the control should be more sensitive to the environment and report more suspect activity.

Log Management

Logging is an important activity for security personnel. **Log files** can help provide evidence of normal and abnormal system activity as well as valuable information on how well the controls are doing their jobs. The security and systems administrators must consider several things to ensure you are keeping the right information and that information is secure.

First, you should store logs in a central location to protect them and to keep them handy for thorough analysis. Be sure to have lots of storage space available and monitor your log file disk space requirements. If a log file fills up, there are only three bad choices possible:

- Stop logging
- Overwrite the oldest entries
- Stop processing (controlled or crash)

Attackers sometimes purposely fill a log file with extraneous messages to cause one of these failures. Therefore, the storage device for log files must be large enough to prevent this possibility. In addition, the logging settings must not impose artificially low log file size constraints.

NOTE

To find a list of NTP servers, see *http://tf.nist.gov/tf-cgi/servers.cgi*.

Keeping Log Files

Regulation, policy, or log volume might dictate how much log information to keep. If a log file is subject to litigation, a company must keep it until the case is over, but, if litigation is not underway, a company

can generally make its own decisions about log quantity and retention, subject to any regulations or standards with which it must comply. Once litigation begins, providing the data in those logs is a costly process that the company must bear. However, a company can lower litigation costs by limiting the quantity of data collected in logs to only what is needed and keeping the data for only as long as it is likely to be useful.

In some cases, regulations may specify how long a company must keep data. For example, the PCI DSS requires that logs be kept for at least one year. Therefore, it's always best to have a written retention standard because, that way, if necessary, the company can explain in court that deleted logs were part of its normal business practice rather than an attempt to destroy evidence.

Remember that log files contain entries that describe events on a specific computer or device. Thus, to link activities between systems and logs, computers and devices on the network must have synchronized clocks, a function provided by Network Time Protocol (NTP). Most modern routers and servers have this function, whereas international government-run NTP servers provide an unbiased third party to supply the time.

It is important to protect all log files from unauthorized access, deletion, or changes. To prevent overwriting or modification, some systems write logs to a write-only device or send log messages to a write-only logging service. Protecting logs from modification or read access makes it hard for an attacker to clean up traces of the attack. Log files that are easy to access make it easy for an attacker to remove log file entries linked to the attack. Moreover, log files often contain confidential information about users or information, which you might need to provide evidence for an investigation.

Types of Log Information to Capture

An organization might need a large number of logs to record all the activity on its systems, networks, and applications. The four main types of logs that you need to keep to support security auditing include the following:

- **Event logs**—General operating system and application software events
- **Access logs**—Access requests to resources
- **Security logs**—Security-related events
- **Audit logs**—Defined events that provide additional input to audit activities

As shown in **FIGURE 10-3**, you should record all suspicious activity, errors, unauthorized access attempts, and access to sensitive information. As a result, you will not only track incidents, but you will also keep users accountable for their activities.

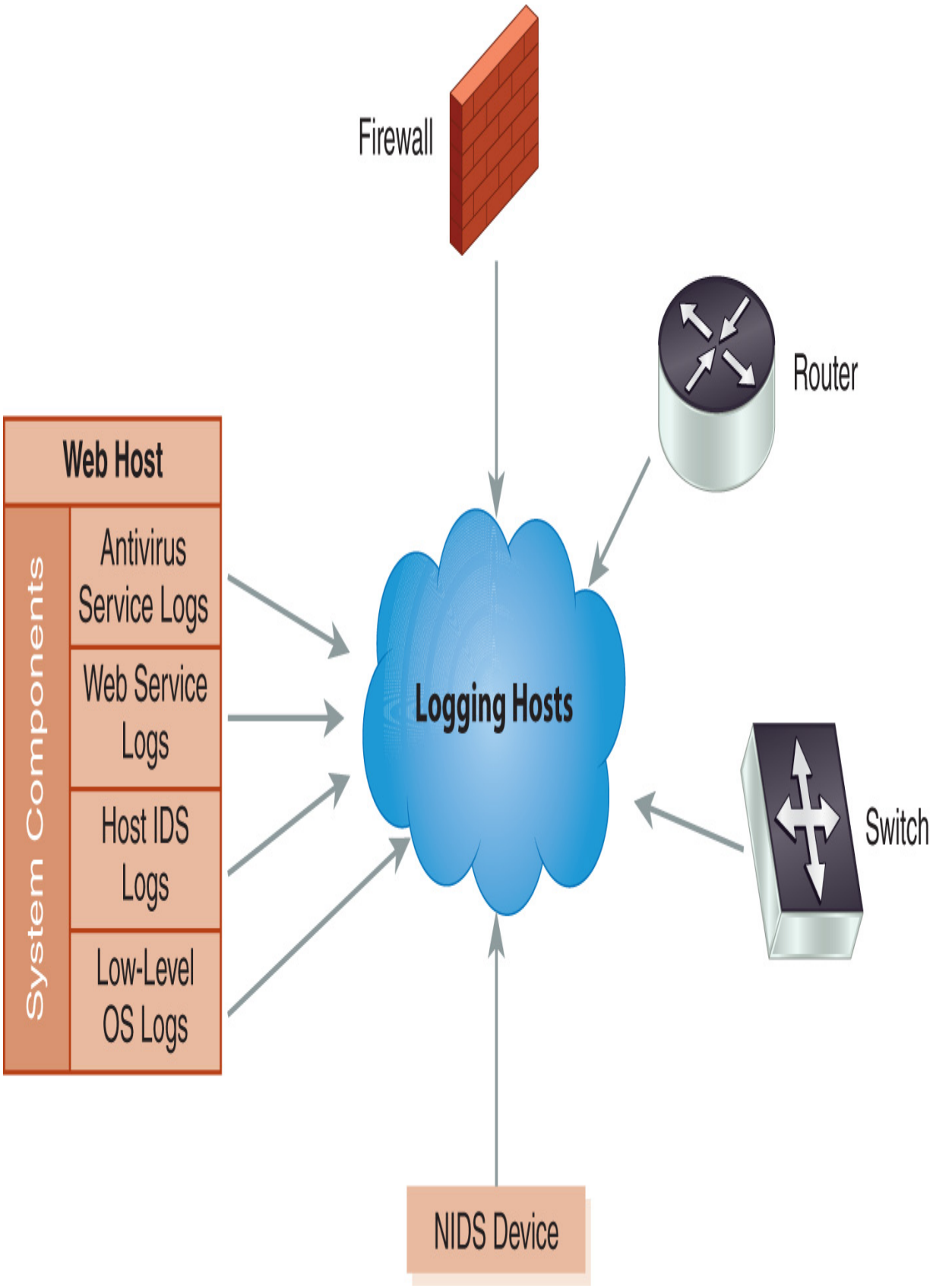

Firewall
Router
Web Host
System Components
Antivirus Service Logs
Web Service Logs
Host IDS Logs
Low-Level OS Logs
Logging Hosts
Switch
NIDS Device

FIGURE 10-3 Types of log information.

The **security information and event management (SIEM) system** helps organizations manage the explosive growth of their log files by providing a common platform to capture and analyze entries. Organizations collect log data from sources such as firewalls, IDSs and IPSs, web servers, and database servers and have multiple brands or versions of these systems. SIEM collection and analysis devices take the log data in whatever format it is created, from whatever device creates it, and standardize the data into a common format, which is then stored in a database for easy access. One of the more popular features of most SIEM systems is the collections of visual charts and graphical representations of collected data that are organized into an easy-to-read interface called a SIEM dashboard. SIEM dashboards are generally organized for quick and accurate interpretation of a system's real-time status. You can run SIEM vendor-supplied or custom reports against those databases to access and analyze log file information. SIEM systems are an integral source of information for an organization's security operations center (SOC). SOC personnel rely on accurate and timely data to make critical cybersecurity defense decisions, and SIEM systems can provide that input.

As operating system, application software, and network device vendors change products, the new log file formats may be different from previous products. If an organization uses a SIEM system to handle its log files, such format changes are not critical because you can merge files from the new products into the same database without limiting the ability to produce reports that cover the before-and-after time period.

SIEM systems monitor user activity and ensure that users act only in accordance with policy, and that means that SIEM systems are a valuable method of ensuring regulatory compliance. They can also integrate with identity management schemes to ensure that only current user accounts are active on the system. Even though SIEM systems do a great job of collecting and integrating security-related information, they do not do much to help organizations respond to identified incidents. To perform that function, you will need a **security orchestration, automation, and response (SOAR) system**, which extends the SIEM functionality to enable an organization to identify any incidents and respond to them in a structured manner.

How to Verify Security Controls

One specific class of monitoring controls can provide a very good layer of security. This class of controls monitors network and system activity to detect unusual or suspicious behavior, and some controls in this class can even respond to detected suspicious activity and possibly stop an attack in progress. Controls that monitor activity include IDSs, IPSs, and firewalls.

NOTE

There are two important types of primary security controls: preventive and detective. A *detective control* (i.e., IDS) simply detects when a defined event occurs, whereas a *preventive control* (i.e., IPS) prevents the event from ever happening.

Intrusion Detection System

Layered defense requires multiple controls to prevent attacks, and one of the most common layered-defense mechanisms is to place an IDS or IPS behind a firewall to provide increased security. A network IDS (NIDS) monitors traffic that gets through the firewall to detect malicious activity. A HIDS or host-based IPS (HIPS) (both covered later in the chapter) will do the same for traffic destined for a particular computer or device. Because the HIDS/HIPS sees a narrower view, you can tune it to detect very specific activities. Unlike the NIDS, the HIDS/HIPS will also see traffic that originates inside the perimeter. **FIGURE 10-4** shows a network with a NIDS and a HIDS/HIPS device.

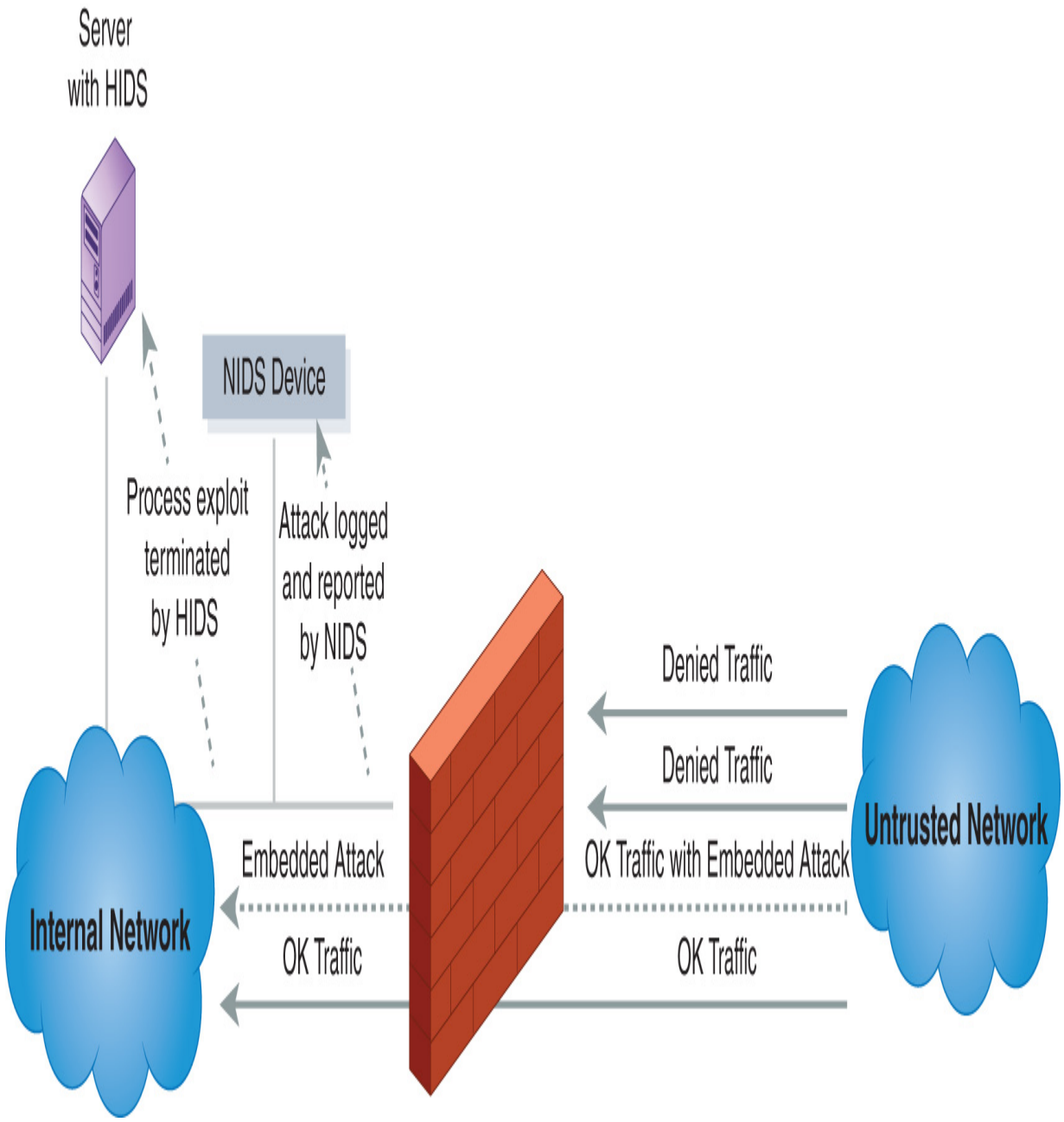


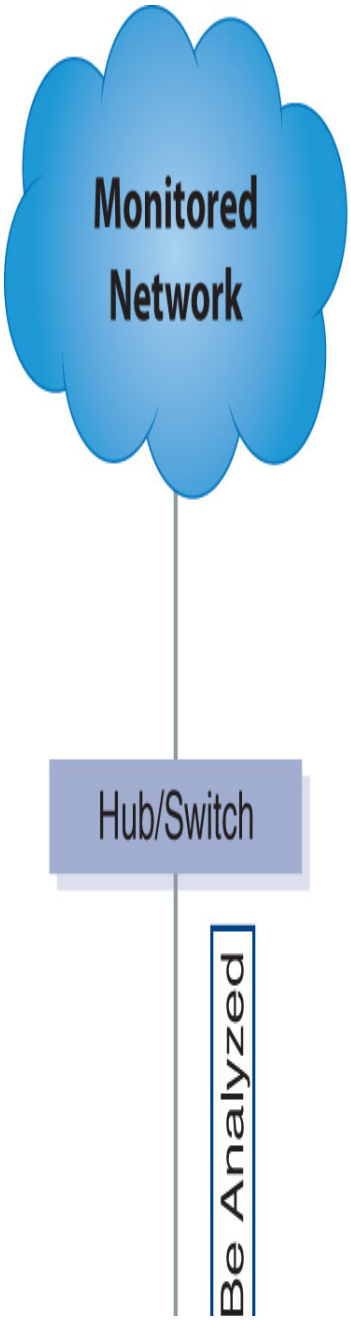
FIGURE 10-4 IDS as a firewall complement.

NOTE

Administrators commonly configure a NIDS without an Internet Protocol (IP) address on its monitoring port, which makes it extremely difficult for the outsider to send packets to or otherwise directly address the NIDS.

Administrators reach the device via another interface, which should be on a different subnet.

As shown in **FIGURE 10-5**, you can connect a NIDS to a switch or hub. The IDS then captures all traffic on the switch and analyzes it to detect unauthorized activity. The method used for analysis depends on the type of engine in the IDS.



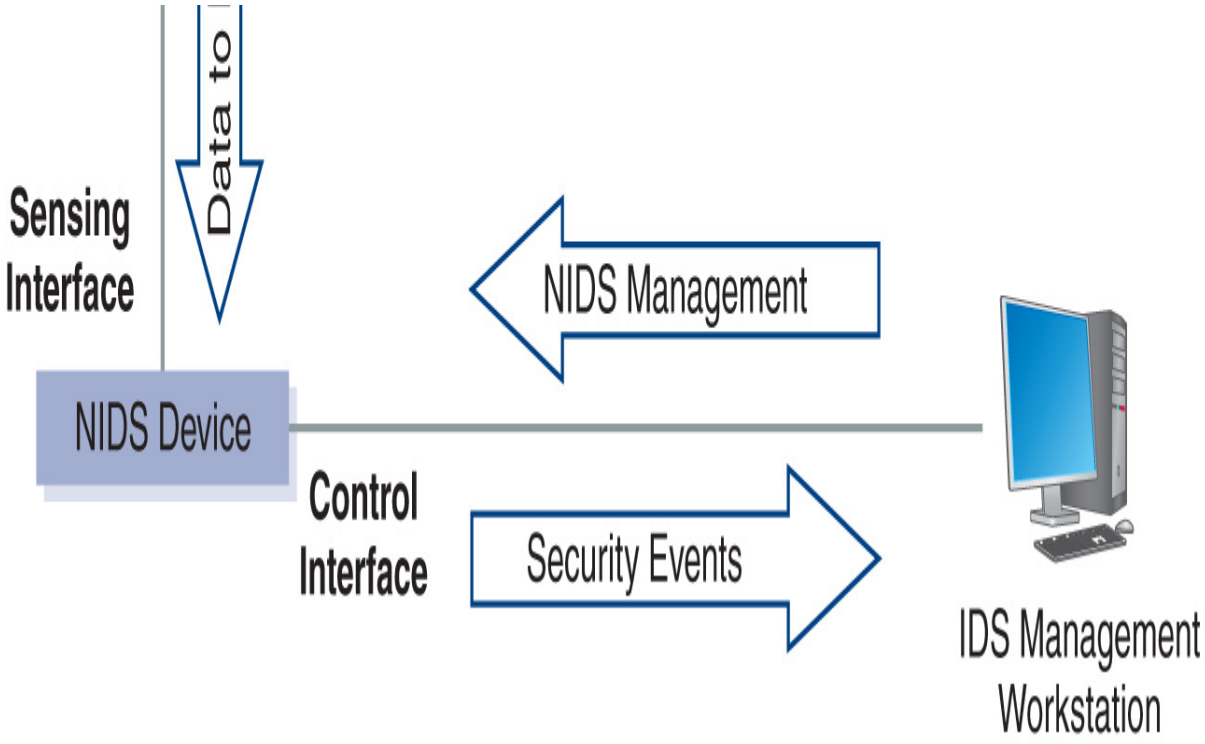


FIGURE 10-5 Basic NIDS as a firewall complement.

The IDS connects to a management console that lets the administrator monitor and manage it and, ideally, will not be detectable from the network. That means attackers will not be able to determine where the IDS is positioned on the network. The administration port on the IDS is not accessible from the network, which prevents an attacker from altering the configuration of the IDS.

Analysis Methods

Monitoring and detection devices use several methods to analyze traffic and activity to know when to raise an alert or alarm. Some of these methods compare network packets or addresses to rules, whereas others look at the frequency and type of activity. These two methods are called pattern- or signature-based and anomaly- or statistical-based IDSs.

Pattern- or signature-based IDSs, using what is known as rule-based detection, rely on pattern and stateful matching to compare current traffic with activity patterns (signatures) of known network attacks. Pattern-matching systems scan packets to see whether specific byte sequences,

known as *signatures*, match the signature of known attacks. Often, the patterns are related to a certain service and port (source or destination). To avoid this type of control and attempt to escape detection, many attackers change their attacks so they have unknown signatures. Therefore, you must frequently update your signature files to ensure that you can detect the latest known attacks. **Stateful matching** improves on simple pattern matching in that it looks for specific sequences appearing across several packets in a traffic stream, rather than just in individual packets. Although more detailed than pattern matching, stateful matching can still produce false positives. Like pattern matching, stateful matching can detect only known attacks and needs frequent signature updates.

NOTE

False positives are a problem with pattern matching because these systems report close matches, particularly if the pattern lacks granularity, for example, if it's not unique.

Anomaly-based IDSs, also called *profile-based systems*, compare current activity with stored profiles of normal (expected) activity and are only as accurate as the accuracy of the definition of "normal activity." Once you define normal system operation, the IDS compares current activity to what you consider normal activity, and anything the IDS considers abnormal is a candidate for analysis and response. The more common methods of detecting anomalies include the following:

- **Statistical-based methods**—These methods develop baselines of normal traffic and network activity, and the device creates an alert when it identifies a deviation. They can catch unknown attacks, but false positives often happen because identifying normal activity is difficult.
- **Traffic-based methods**—These methods signal an alert when they identify any unacceptable deviation from expected behavior based on traffic. They can also detect unknown attacks and floods.

- **Protocol patterns**—Another way to identify attacks without a signature is to look for deviations from protocols. Protocol standards are provided by Request for Comments (RFC) memorandums published by the Internet Engineering Task Force (IETF). You can get more information on RFCs at *https://ietf.org/standards/rfcs/*. This type of detection works for well-defined protocols but may cause false positives for protocols that are not well defined.

HIDS

HIDS technology adds to an entire system's protection by keeping watch over sensitive processes inside a computer, also called a *host*. HIDS (and HIPS) systems generally have the following qualities:

- They are usually software processes or services designed to run on server computers.
- They intercept and examine system calls or specific processes (e.g., database and web servers) for patterns or behaviors that should not normally be allowed.
- HIDS/HIPS daemons can perform a predefined action, such as stopping or reporting the infraction.

HIDS/HIPS also have a different point of view than NIDSs. A HIDS/HIPS can detect inappropriate traffic that originates inside the network and recognize an anomaly that is specific to a particular machine or user. For example, a single user on a high-volume mail server might originate 10 times the normal number of messages for a user in any day (or hour), activity that the HIDS/HIPS would notice and issue an alert for, whereas a NIDS may not notice this reportable event. To the NIDS, it just looks like increased network traffic.

Layered Defense: Network Access Control

The best defense is to have multiple layers of controls in place, because having multiple layers increases the chances of successfully protecting the system from more attacks than would be possible with just a single control.

FIGURE 10-6 shows how network devices work in multiple layers to try to prevent an attack on the internal protected network. The router detects and filters out some traffic, and the firewall detects and stops unwanted traffic.

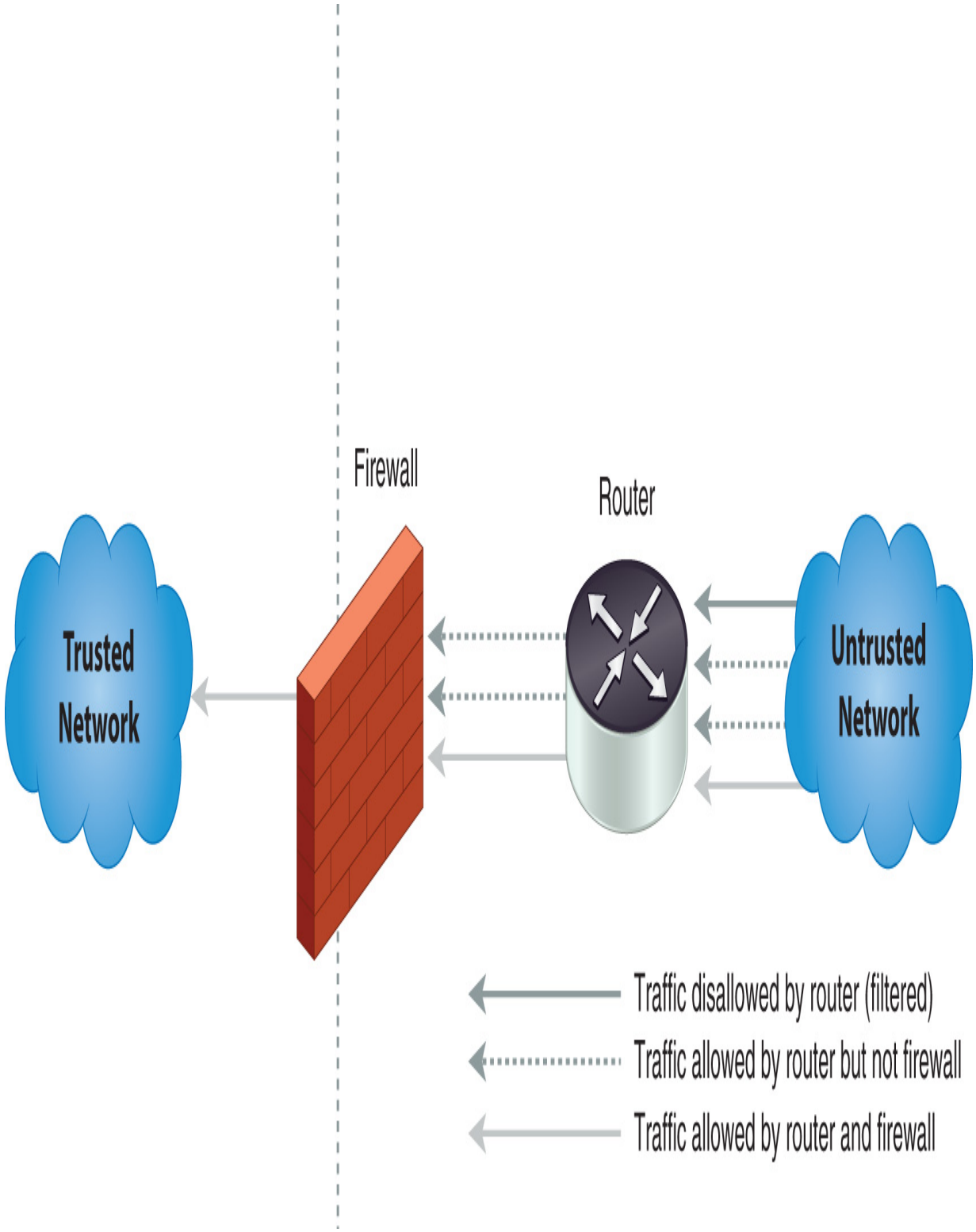


FIGURE 10-6 Layered network devices trying to prevent an attack on the internal protected network.

Control Checks: Intrusion Detection

A NIDS is an important component in any multilayered defense strategy. **FIGURE 10-7** shows how a NIDS can monitor outside attacks as well as insider misuse. A NIDS outside the network gives some idea of the types of attacks faced by the firewall, whereas the internal NIDS detects the types of attacks that may get by the firewall. You can also install this device as an IPS. That way, the device can not only detect a potential attack, but it can also change its rules to filter traffic to stop the attack. These devices also work well with HIDS devices. While the NIDS helps protect a system from malicious network traffic, the HIDS will see the types of activity being attempted on the host itself.

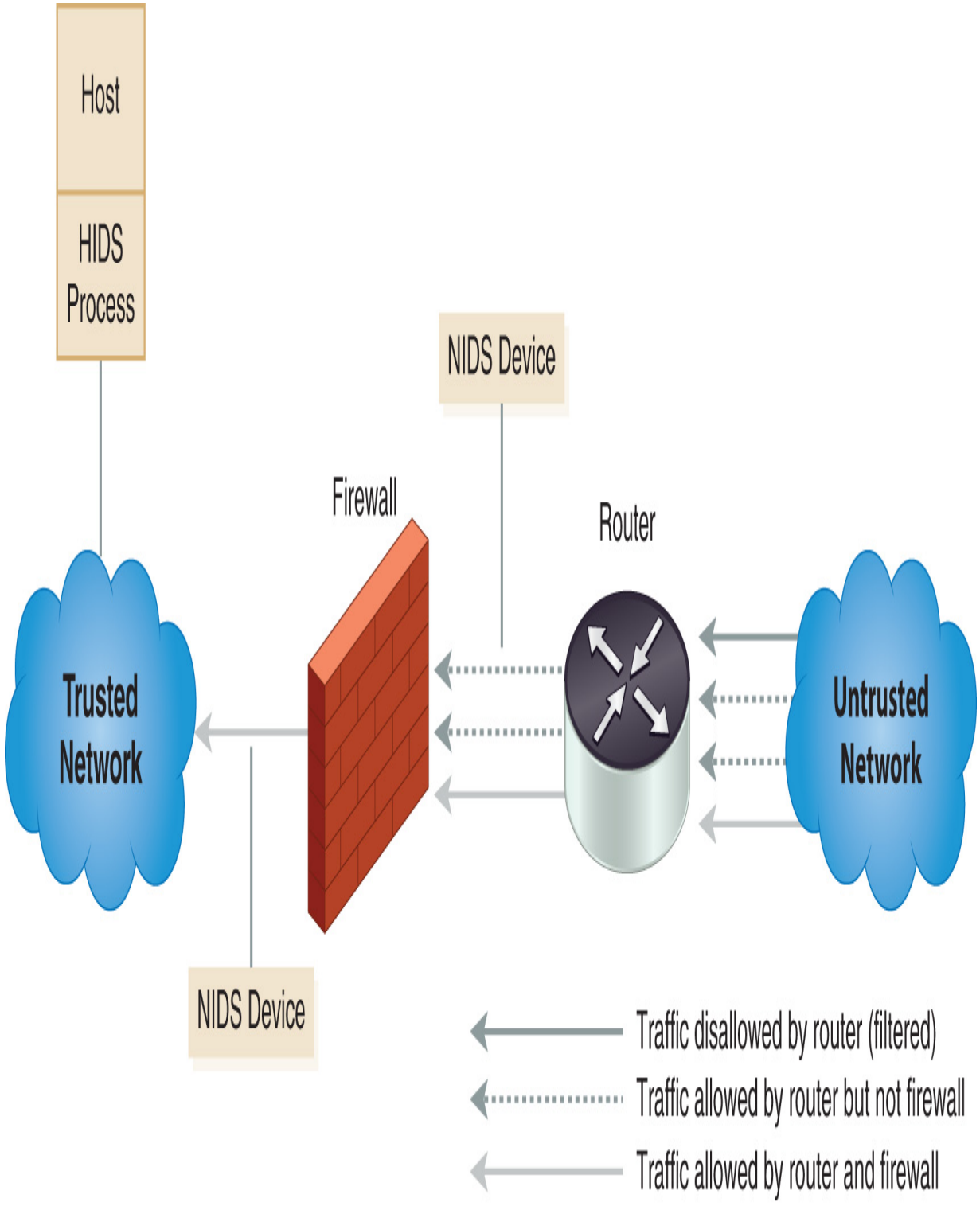
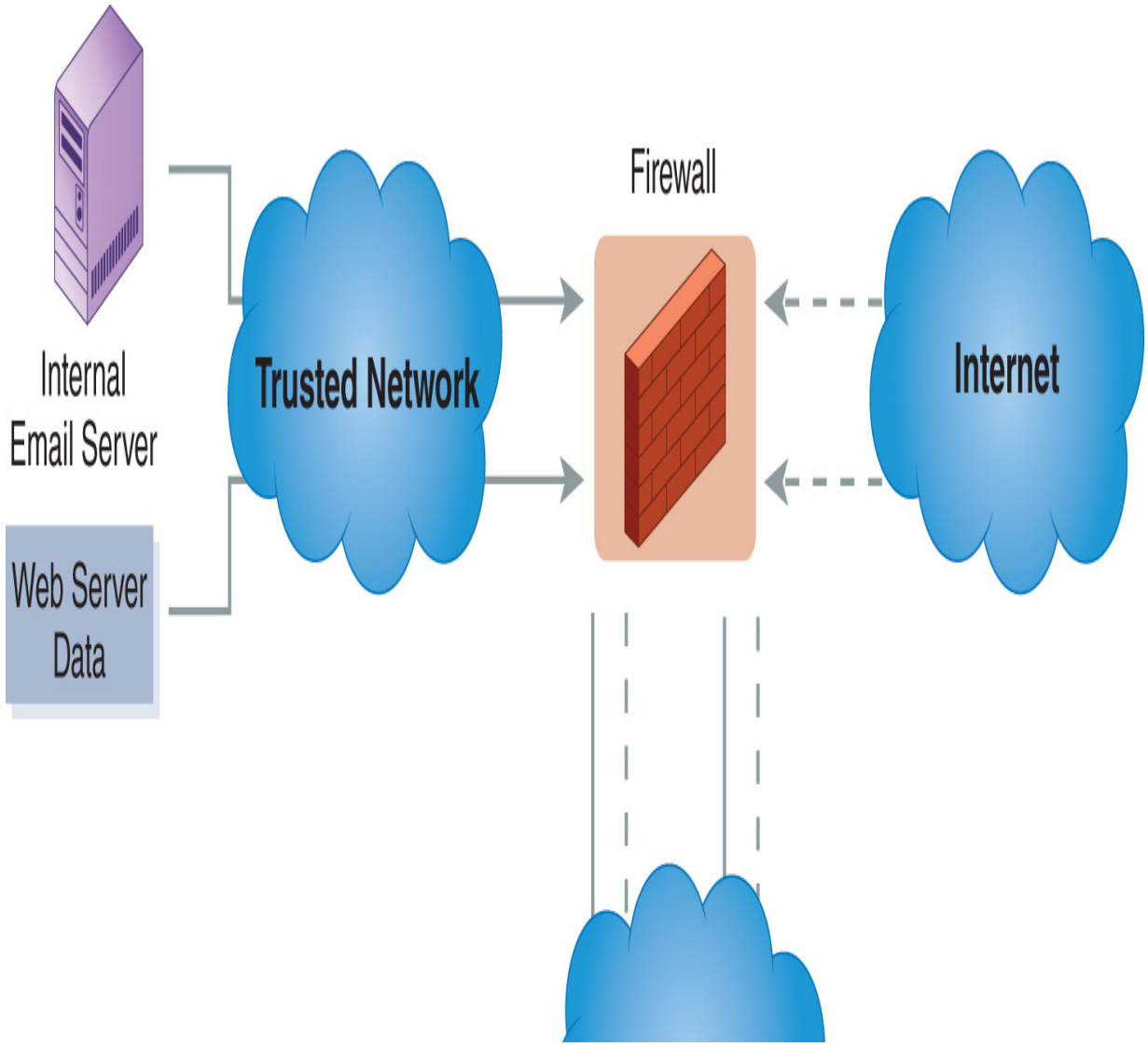


FIGURE 10-7 Using NIDS devices to monitor outside attacks.

Host Isolation

Some servers, or hosts, must be open to the Internet, web servers being an example. Any user should be able to access the web server, but not everyone should be able to get to the internal network. A simple solution is to isolate the hosts connected to the Internet from the rest of the network. Host isolation isolates one or more host computers from the internal networks and creates a demilitarized zone (DMZ). **FIGURE 10-8** shows a DMZ with two isolated hosts. A DMZ is a physical or logical subnetwork that contains and exposes an organization's external services to a larger untrusted network, usually the Internet. Outside traffic from the untrusted Internet is allowed only into the DMZ, where it can get to certain company services, and then the web applications in the DMZ access the trusted internal network but prevent the outside user from getting directly to the internal network.



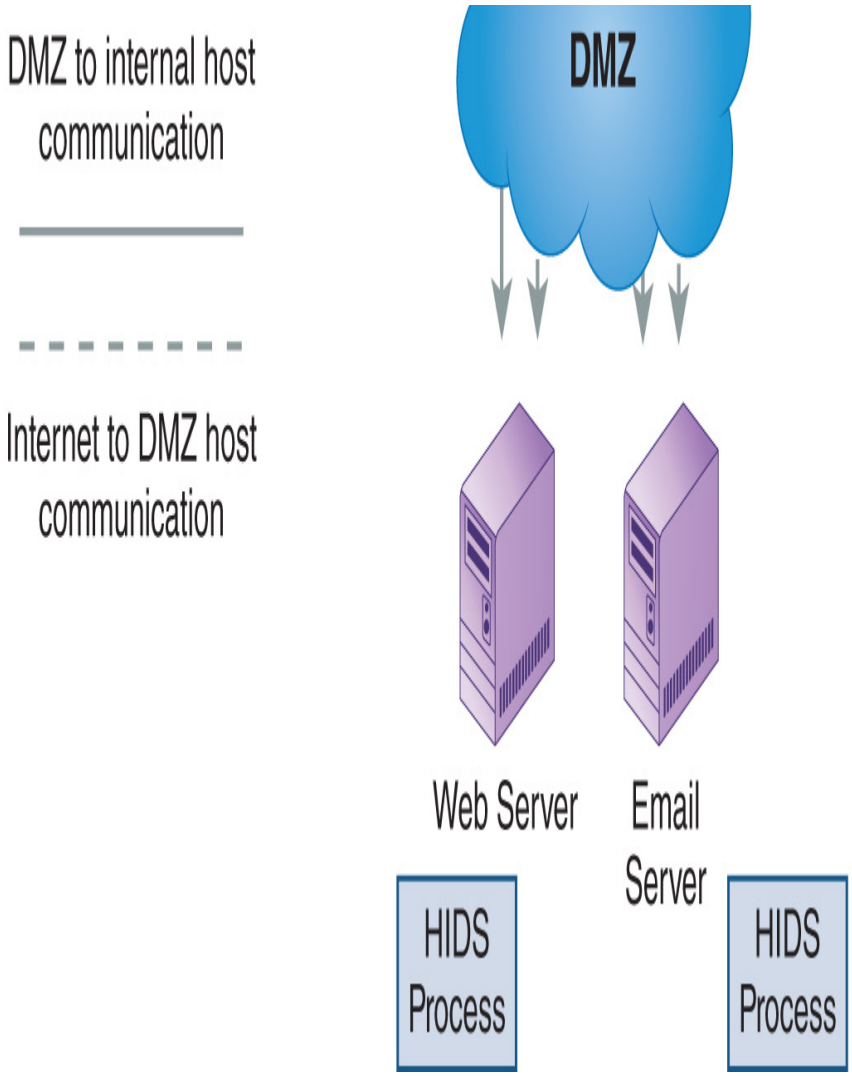


FIGURE 10-8 Host isolation and the DMZ.

System Hardening

No computer is completely secure, and, in fact, very few operating systems or application software packages are secure when you install them. It is important that security administrators go through a process called **hardening** to change hardware and software configurations to make computers and devices as secure as possible. A computer or device with a **hardened configuration** is one on which you have carried out the following minimal actions:

- Turned off or disabled (or even uninstalled) unnecessary services and protected the ones that are still running
- Secured management interfaces and applications
- Protected passwords through aggressive password policies
- Disabled unnecessary user accounts
- Applied the latest software patches available
- Secured all computers and devices from any unauthorized modification

In addition to hardening systems, it is important to harden the network as well. There are many opportunities to harden networks, but just a few steps go a long way toward making the networks (and network devices) more secure. Those steps include the following:

- Disabling unused network interfaces
- Disabling unused application service ports
- Using Media Access Control (MAC) filtering to limit device access
- Implementing 802.1x, port-based Network Access Control (PNAC)

Harden all systems before implementing them because failing to do so before putting them into production almost certainly will result in their compromise.

Set a Baseline Configuration

After hardening a computer or device, you must document and store the hardened configuration settings. That way you can compare the hardened configuration against known secure configurations. You can also compare the configuration settings in the future with the original settings to see whether any unauthorized changes have occurred. Creating a baseline makes it easy to ensure that security is consistent between the various systems. When it is easy to define standard settings, you can more easily control individual system differences. For example, you can decide whether to allow certain services or applications on an individual computer if you know that its basic configuration meets your standards.

Disable or Remove Unnecessary Services

One of the easiest and most effective steps to harden computers is to shut down or remove unneeded services and programs. For example, many server computers run web servers even if they do not host a website or any web-based services, and attackers search for these unneeded services to try to exploit their vulnerabilities. You should disable unnecessary services or, even better, uninstall them, the reason being that attackers cannot attack programs that are not there. Close unneeded firewall ports and restrict certain services, such as mobile code, Telnet, and File Transfer Protocol (FTP). You should configure firewalls to deny anything not specifically allowed, which will stop attackers from secretly adding new and unexpected services.

Be sure to harden all routers and other devices, too. Protection should be in place against unauthorized administrator access and changes to router tables. Network devices ship with either no passwords or default passwords, so you should change the default passwords before connecting any device to the network. You manage these device passwords like any other password in that they should be complex and changed regularly. You must document any changes to network devices and log the user ID of the administrator making the changes. Finally, you should examine all configuration logs on a regular basis, perhaps by a SIEM or SOAR implementation.

Servers and network devices are not the only items you need to harden; do not forget about endpoints and IoT devices. Workstations and mobile devices need a standard configuration and access controls. Organizations should have a hardened image for workstations and approved IoT devices. You can create a standard image by installing a fresh copy of an operating system and hardening it. Be sure to remove unnecessary services and add security products, such as antivirus software and personal firewalls. The image should also contain company-standard software, such as a word processor, spreadsheet, and browser plug-ins. Once the image meets the organization's standards for workstations, you can use the image as a starting point for all new desktops and laptops. This process can help ensure security compliance and reduce maintenance time.

Physically protect servers, perhaps behind locked doors. Make sure all computers and devices have the latest patches applied. You can use third-party patch management software to track patches issued by all vendors of all

products installed on a company's computers and devices. Some products even have automatic "phone-home" patch management.

In most cases, the best solution for servers exposed to the Internet is to make sure you do not use those servers for any other purpose. For example, a computer that is located in a DMZ and functions as a web server should not provide any other services.

Review Endpoint Protection Programs

An audit of the system should include a review of the antivirus and other anti-malware programs an organization uses as well as any additional controls intended to secure endpoints. Additional controls can include endpoint detection and response (EDR) tools that monitor endpoints for suspicious behavior, DLP tools that help limit data leakage, and firewalls (host and network based) to filter traffic from and to endpoints. This review should ensure that all software products and their data are up to date. Perform antivirus scans periodically on all network devices and computers. Schedule a full scan of all systems on a regular basis, and scan all application servers, workstations, and gateways.

Monitoring and Testing Security Systems

Securing a closed environment is difficult. Therefore, the main goal of a security professional is to protect an organization's sensitive data from attackers. As hard as it is to secure a closed system, the job becomes far more difficult when the network connects to the Internet. Connecting to the Internet rolls out a red carpet for attackers. The job of the security professional is to deploy strategies to control access to the systems. Keep in mind that completely securing a system is impossible. Although there are many risks associated with information security, two of the most common risks follow:

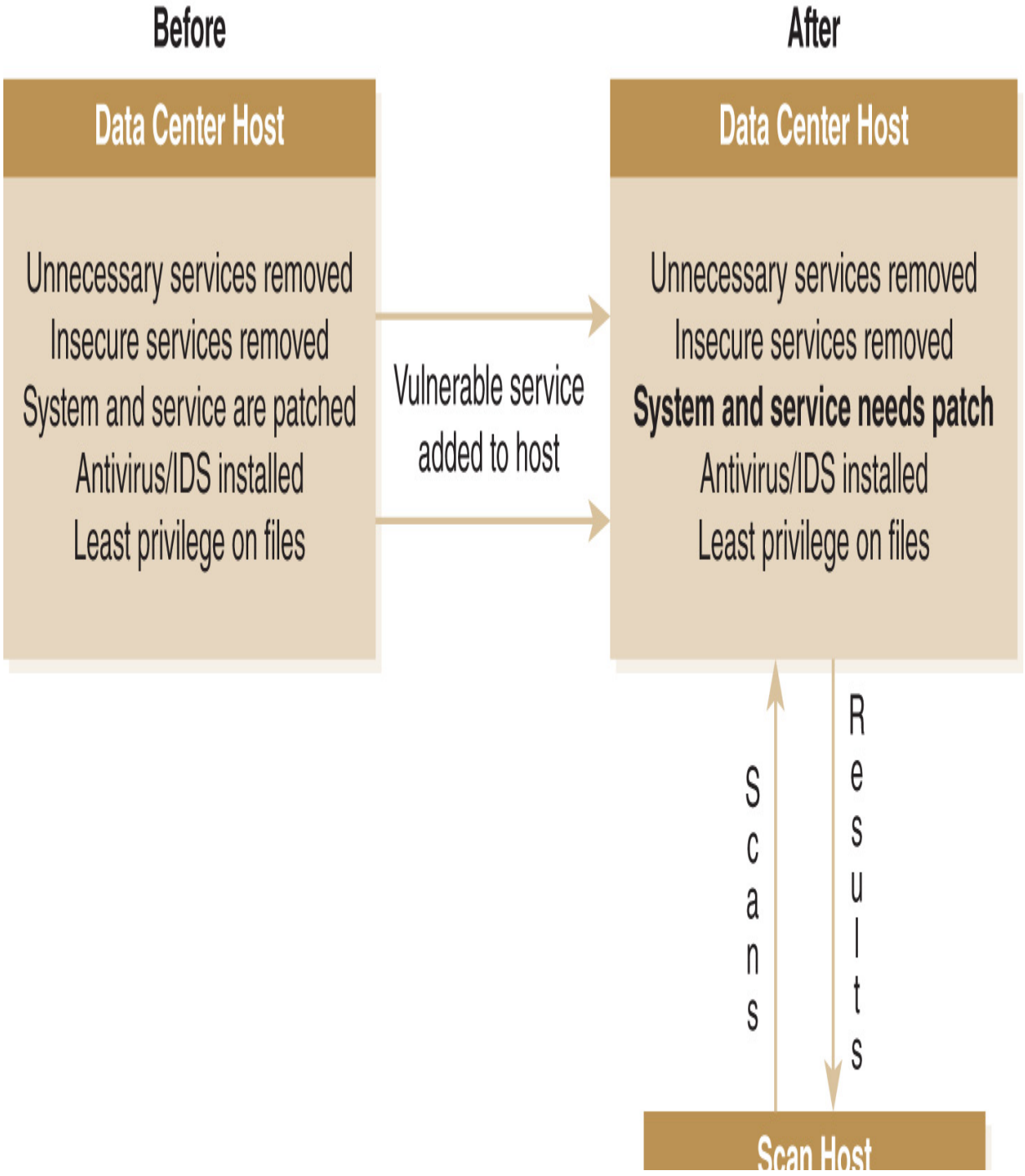
- Attackers who come in from outside, with unauthorized access, malicious code, Trojans, and malware
- Sensitive information leaking from inside the organization to unauthorized people who can damage the organization

Monitoring

How can you prevent the leakage of sensitive information from an organization? The answer is that there is no fail-safe method, but monitoring is key. Of course, you cannot watch every IP packet on your system. Even if you could train humans to do this mind-numbingly boring work, you would not be able to put enough people on it to keep up. Instead, you must monitor your traffic with an IDS. The premise behind an IDS is that it can identify abnormal traffic for further investigation. IPSs go a step further than IDSs by actively blocking malicious traffic. An IDS sends out an alert when it detects potentially unauthorized activity, whereas an IPS blocks it. Of course, before you can use an IDS or an IPS, you must create a baseline definition of normal traffic.

Testing

In addition to monitoring a system, you must test it. The main purpose of any security test is to identify uncorrected vulnerabilities on a system. A system might have been secure at one time, but the addition of a new service or application might have made the system vulnerable. The point of testing is to discover new vulnerabilities so you can address them. **FIGURE 10-9** shows the main goals of security testing.



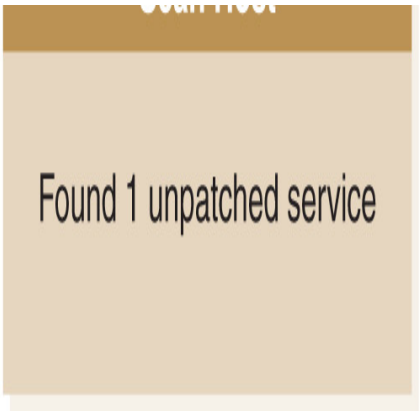


FIGURE 10-9 Security testing.

The frequency of testing depends on such factors as the volatility (rate of changes) of the system and the sensitivity or criticality of the system. Also, policy and regulation often mandate tests. A few of the most common test schedule trigger points are as follows:

- During the security certification phase
- After major system changes (new technology upgrades and application changes)
- New threats
- During system audits
- Periodically, depending on the nature of the system
- Once a year on critical systems

If none of the other items on the list triggers a test, it is still a good idea to schedule tests at least once a year, even on noncritical systems. Some companies might choose shorter or longer testing intervals, depending on a risk analysis.

NOTE

Vulnerability testing tries to find a system's weaknesses, and *penetration testing* is a focused attack to exploit a discovered vulnerability. Attackers follow the same steps as penetration testers with

the difference being that the attackers do not have consent to penetrate the system. The following is a brief overview of each testing type to help point out their differences.

The goals of vulnerability testing include:

- Identifying vulnerability (passively)
- Documenting lack of security control or misconfiguration
- Examining vulnerabilities related to credentialed and noncredentialed users

The goals of penetration testing include:

- Identifying threats
- Bypassing controls
- Exploiting vulnerabilities

A Testing Road Map

No perfect solution exists when it comes to testing, and not every security professional will follow the same path. **FIGURE 10-10** shows a road map for security testing. As shown in the figure, security testing consists of a few common activities that provide a complete view of a system's security. The most common activities include the following:

- **Reconnaissance**—This activity involves reviewing the system to learn as much as possible about the organization, its systems, and its networks. Public resources for the job, such as Whois and Dig, are invisible to network administrators—and this is a problem when they are used by attackers instead of penetration testers.
- **Network mapping**—This phase uses tools to determine the layout and services running on the organization's systems and networks.
- **Vulnerability testing**—Vulnerability testing involves finding all the weaknesses in a system and determining which places may be attack points.

- **Penetration testing**—In this phase, you try to exploit a weakness in the system and prove that an attacker could successfully penetrate it.
- **Mitigation activities—**Any actions intended to reduce or address vulnerabilities are found in either penetration tests or vulnerability tests.

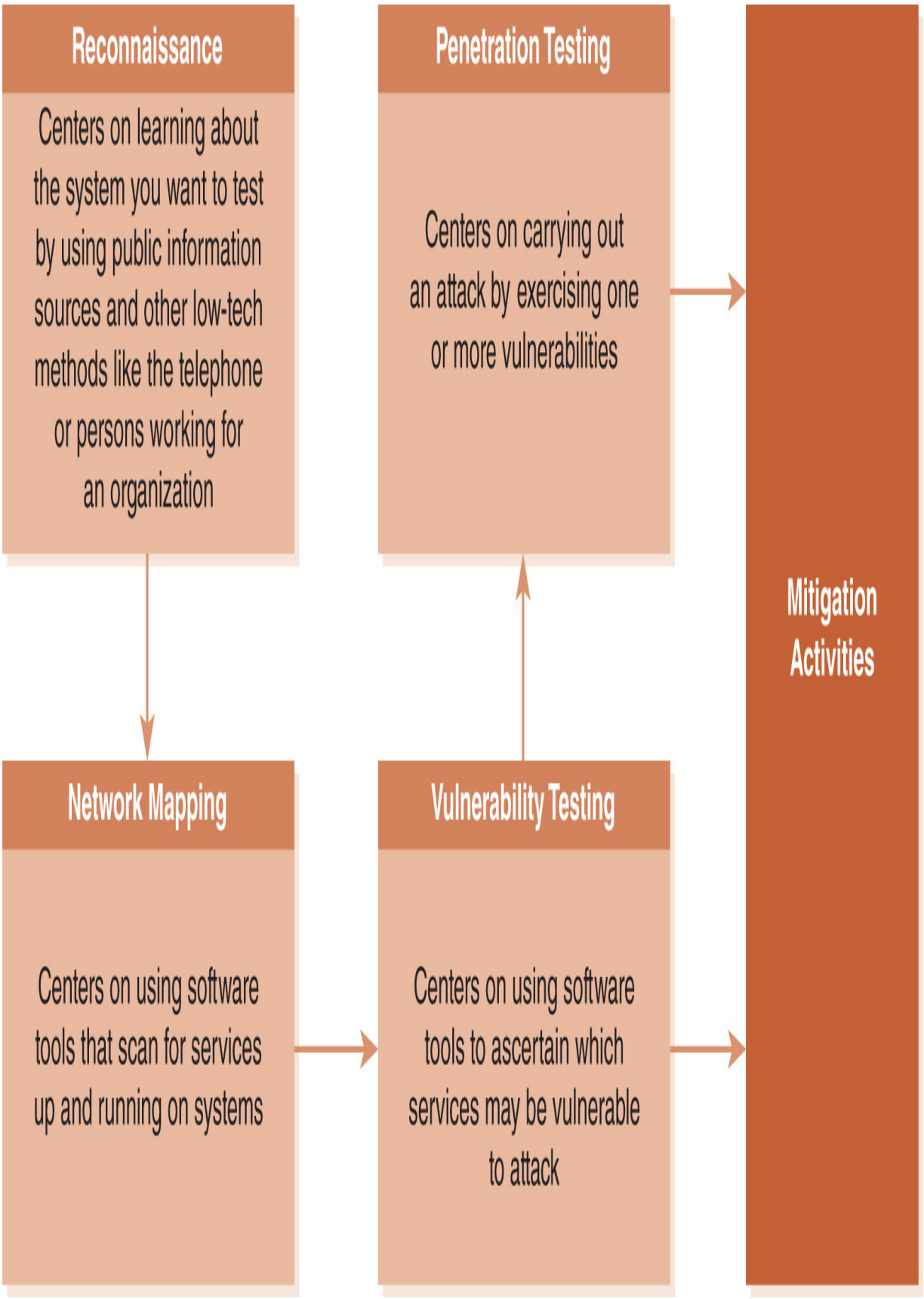

Reconnaissance
Centers on learning about the system you want to test by using public information sources and other low-tech methods like the telephone or persons working for an organization
Network Mapping
Centers on using software tools that scan for services up and running on systems
Vulnerability Testing
Centers on using software tools to ascertain which services may be vulnerable to attack
Penetration Testing
Centers on carrying out an attack by exercising one or more vulnerabilities
Mitigation Activities

FIGURE 10-10 Security testing might take several paths.

Establishing Testing Goals

Before you run your testing procedures, it's important that you establish your testing goals. Security testing is most concerned with evaluating how well controls address vulnerabilities. First, identify vulnerabilities and rank them according to how critical they are to the systems. Next, document a point-in-time (snapshot) test for comparison with other time periods. You want to ensure that your security controls are working properly regardless of the time of day or volume of activity. Then, prepare for an auditor review, which enables an IT staff to tune and test its own procedures using vulnerability analysis in preparation for real audits. Finally, find the gaps in security. This step enables covert testers (discussed in a moment) to determine the likelihood of system compromise and intrusion detection.

Reconnaissance Methods

Reconnaissance is the first and most basic of many tests. In the reconnaissance phase, you gather information through techniques such as social engineering or by researching the organization's website. Attackers use as many types of reconnaissance as possible to gather information about an organization. You should understand what these attackers are doing and then limit their ability to gather information about the organization.

Social engineering is a fancy phrase for lying. It involves tricking someone into sharing confidential information or gaining access to sensitive systems. In many cases, the attacker never comes face-to-face with the victim. Instead, the attacker might phone an employee and pose as a system administrator. All too often, attackers trick employees into sharing sensitive information. After all, employees think, what's wrong with giving their password to an administrator? You should train your users to recognize social-engineering attacks.

Another reconnaissance tool is the Whois service. This service provides information, such as names and phone numbers of administrators, that can help attackers. **FIGURE 10-11** shows the output from a Whois request.

Whois Record for NetworkSolutions.com

− Domain Profile

Registrant	LLC, networksolutions
Registrant Org	Network Solutions LLC
Registrant Country	us
Registrar	Network Solutions, LLC IANA ID: 2 URL: http://networksolutions.com Whois Server: whois.networksolutions.com abuse@web.com (p) 18003337680
Registrar Status	clientDeleteProhibited, clientTransferProhibited, clientUpdateProhibited, serverDeleteProhibited, serverTransferProhibited, serverUpdateProhibited
Dates	8,282 days old Created on 1998-04-26 Expires on 2029-04-25 Updated on 2020-01-31
Name Servers	BARBARA.NS.CLOUDFLARE.COM (has 17,831,156 domains) HENRY.NS.CLOUDFLARE.COM (has 17,831,156 domains)
Tech Contact	LLC, networksolutions Network Solutions LLC 13861 SUNRISE VALLEY DR STE 300, HERNDON, VA, 20171-6126, us domains@web.com (p) 17036684900 (f) 17036685817

IP Address
162.159.128.31 - 7 other sites hosted on this server
IP Location
- California - San Francisco - Cloudflare Inc.
ASN
AS13335 CLOUDFLARENET, US (registered Jul 14, 2010)

FIGURE 10-11 Output from a Whois request.

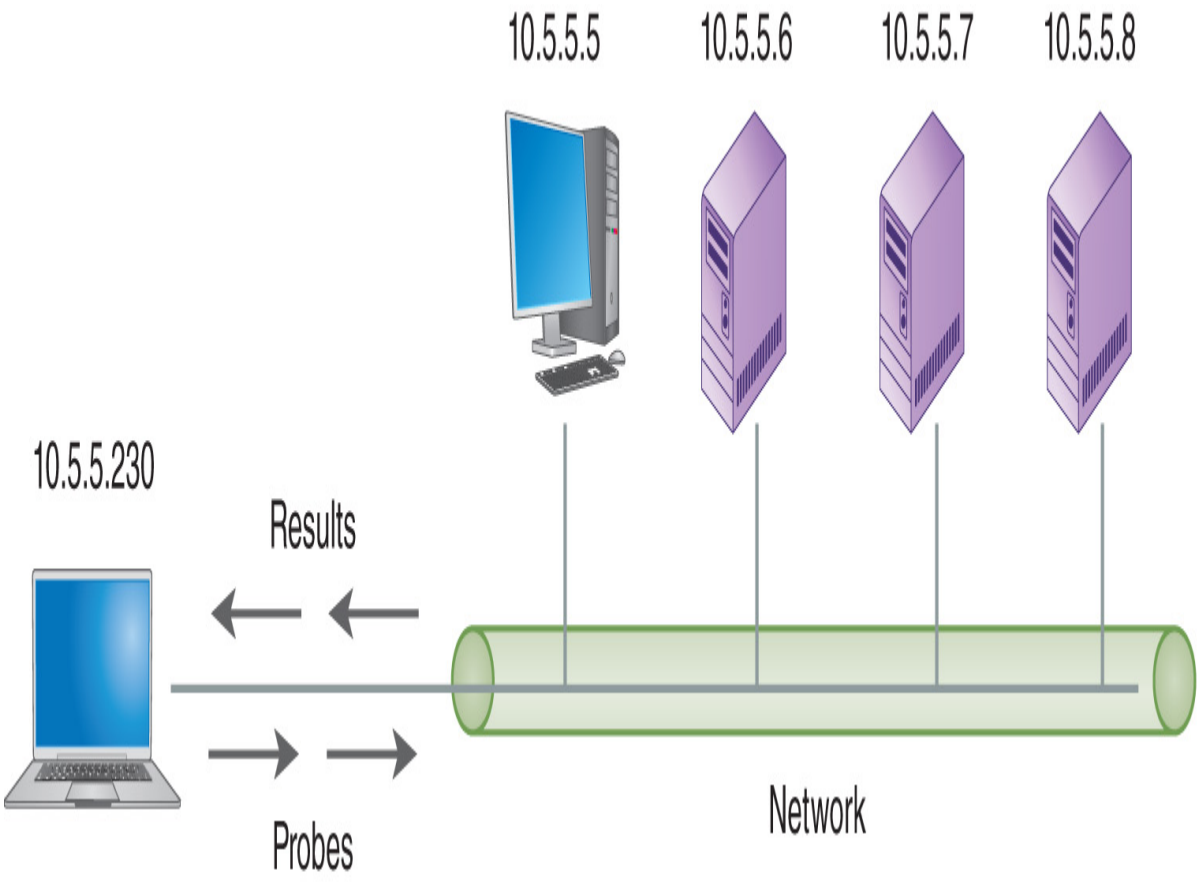
A zone transfer is a unique query of a Domain Name System (DNS) server that asks it for the contents of its zone, which is the domain that the server manages. Administrators often use this tool to synchronize DNS servers within the same organization. If you allow zone transfers without restriction, attackers can use this information to try to figure out the names and types of servers that reside both inside and outside the network. The best defense from this type of information leakage is to lock down the DNS server.

NOTE

Organizations should be very careful to avoid letting their domain name registration lapse because someone else might scoop it up and use it as their own. Such an action could cause great cost to the organization's reputation. This type of social engineering is a bit more sophisticated than the run-of-the-mill variety.

Network-Mapping Methods

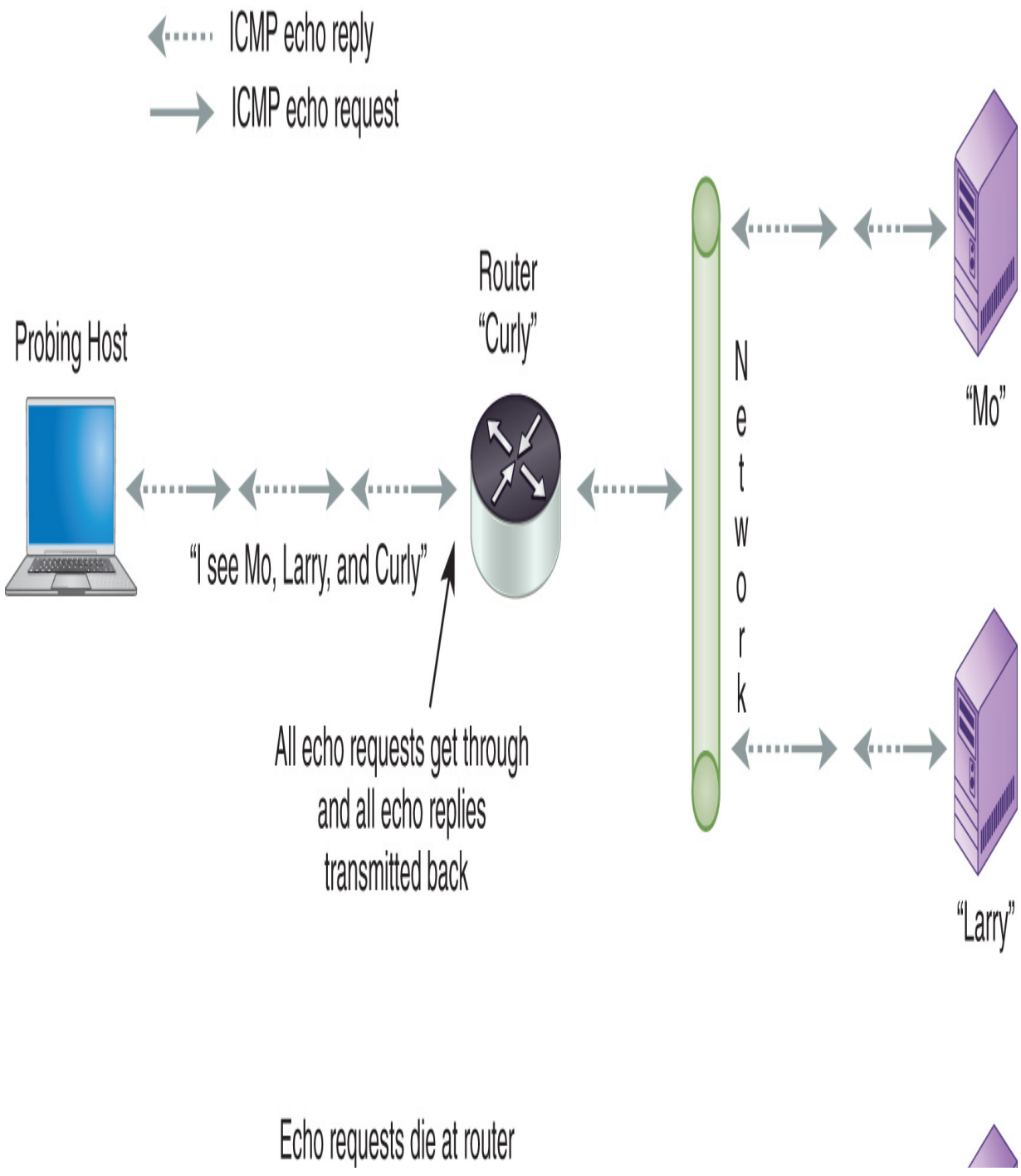
Network mapping is an extended type of reconnaissance in which details are discovered about a network, including its hosts and host addresses as well as available services. This information might enable attackers to identify certain types of systems, applications, services, and configurations. **FIGURE 10-12** shows some of the information that network mapping may provide.



Host Name	IP	Services	OS
user-5	10.5.5.5	http, netbios, ftp	Windows Server 2016
server-6	10.5.5.6	http, netbios	Windows Server 2019
server-7	10.5.5.7	telnet, smtp	Linux
server-8	10.5.5.8	dns, finger, telnet	Solaris

FIGURE 10-12 Network mapping.

An attacker can use Internet Control Message Protocol (ICMP; also known as *ping*) packets to discover a network layout. This gives the attacker an advantage in setting up an attack. As shown in **FIGURE 10-13**, blocking ping packets, as seen with the Tony router, can prevent the attacker from learning about the network. Of course, this also prevents the administrator from being able to use this valuable tool for network troubleshooting.



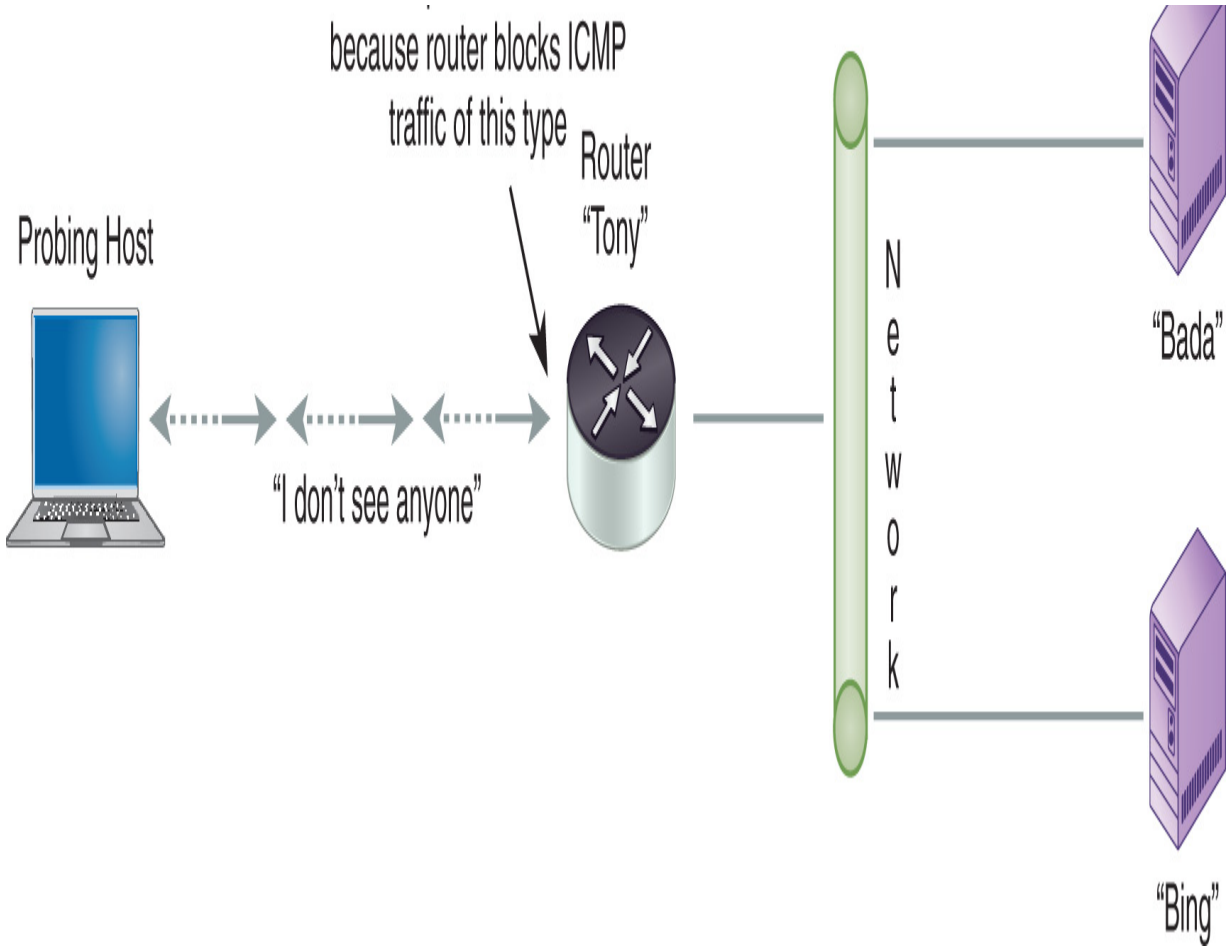


FIGURE 10-13 Network mapping with ICMP (ping).

FIGURE 10-14 shows how an attacker can discover the services available on a target host using TCP/SYN scans. The attacker sends packets to common ports and can determine from the response whether the host accepts these services.

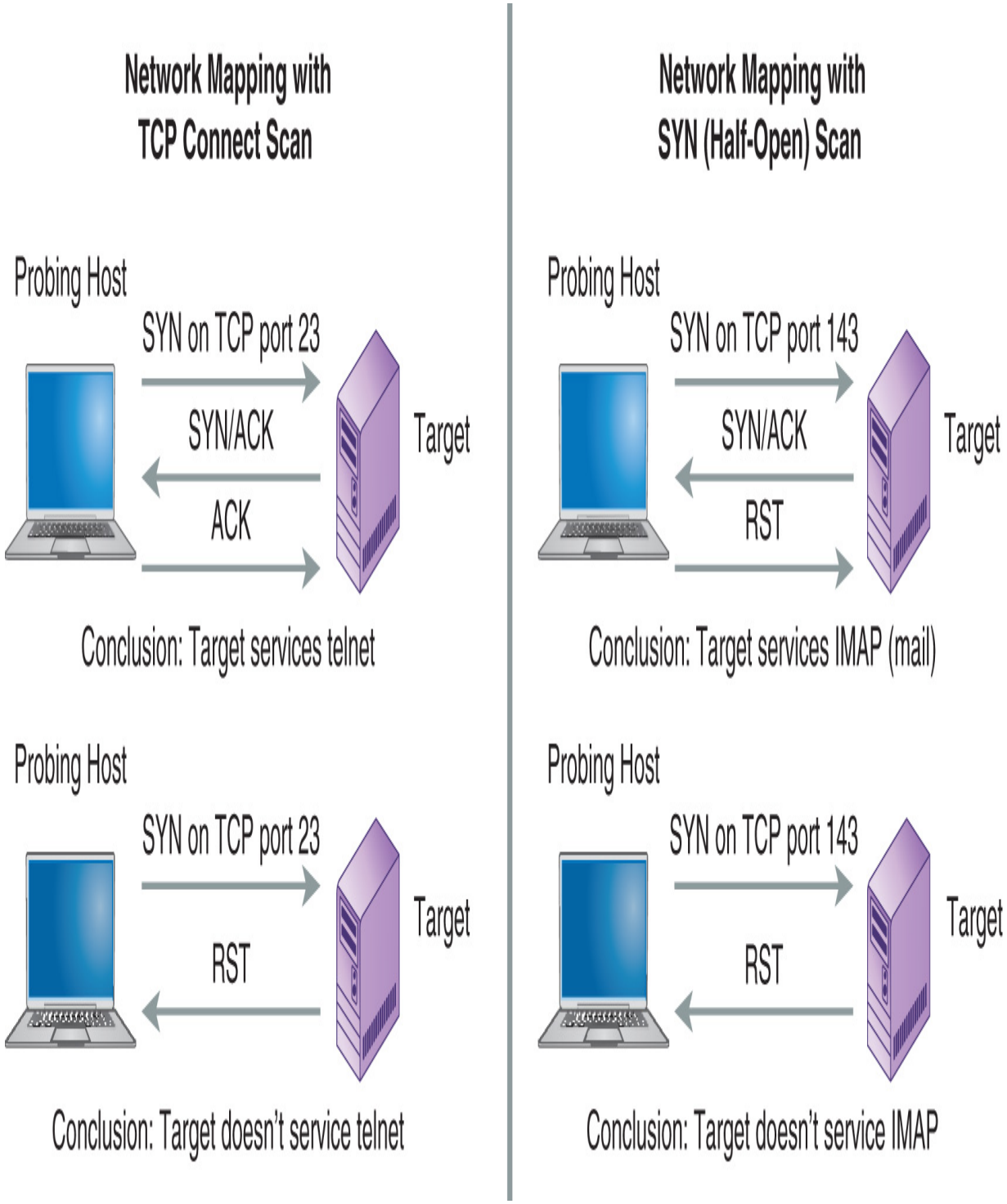
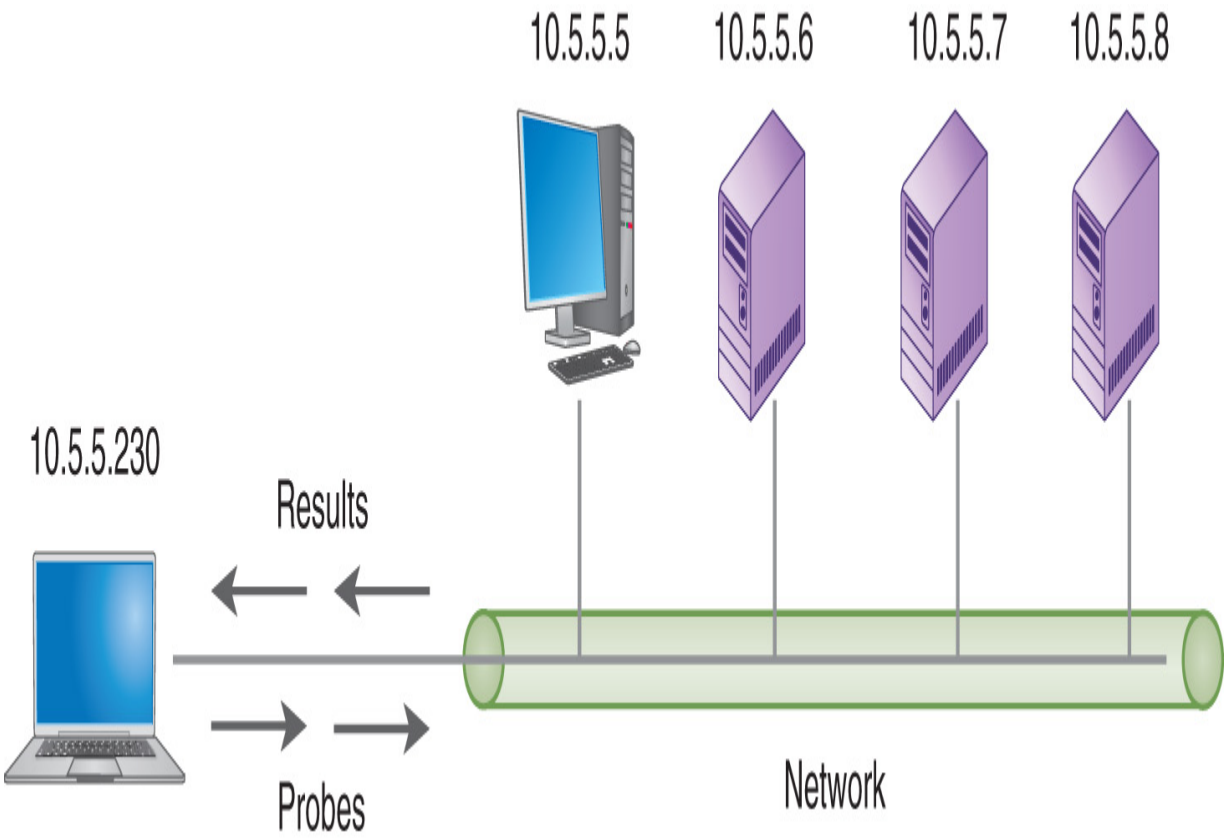


FIGURE 10-14 Network mapping with TCP/SYN scans.

Attackers need to know what operating system a potential victim is running because the approach to attacking a system differs based on the target operating system. With **operating system fingerprinting**, an attacker uses

port mapping to learn which operating system and version are running on a computer. This can also help an attacker discover computers that might be vulnerable because they do not have patches or may have known exploits. **FIGURE 10-15** shows how operating system fingerprinting can provide attackers with valuable information.



What port mappers "think":

- 10.5.5.5 looks like Windows Server 2016 based on the way its TCP/IP communications are structured....
- 10.5.5.6 looks like Windows Server 2019 because it did not respond with an RST when I sent a FIN and it runs IIS 5 according to the http banner....
- 10.5.5.7 looks like Linux because it did send back an RST in response to my FIN and its TCP/IP communications behave like Linux....

FIGURE 10-15 Operating system fingerprinting.

Covert Versus Overt Testers

You can carry out security testing—which can involve both internal and external staff—overtly or covertly. The personnel and methods used might depend on regulations or on the skill level of internal staff. **FIGURE 10-16** shows the various types of testers.

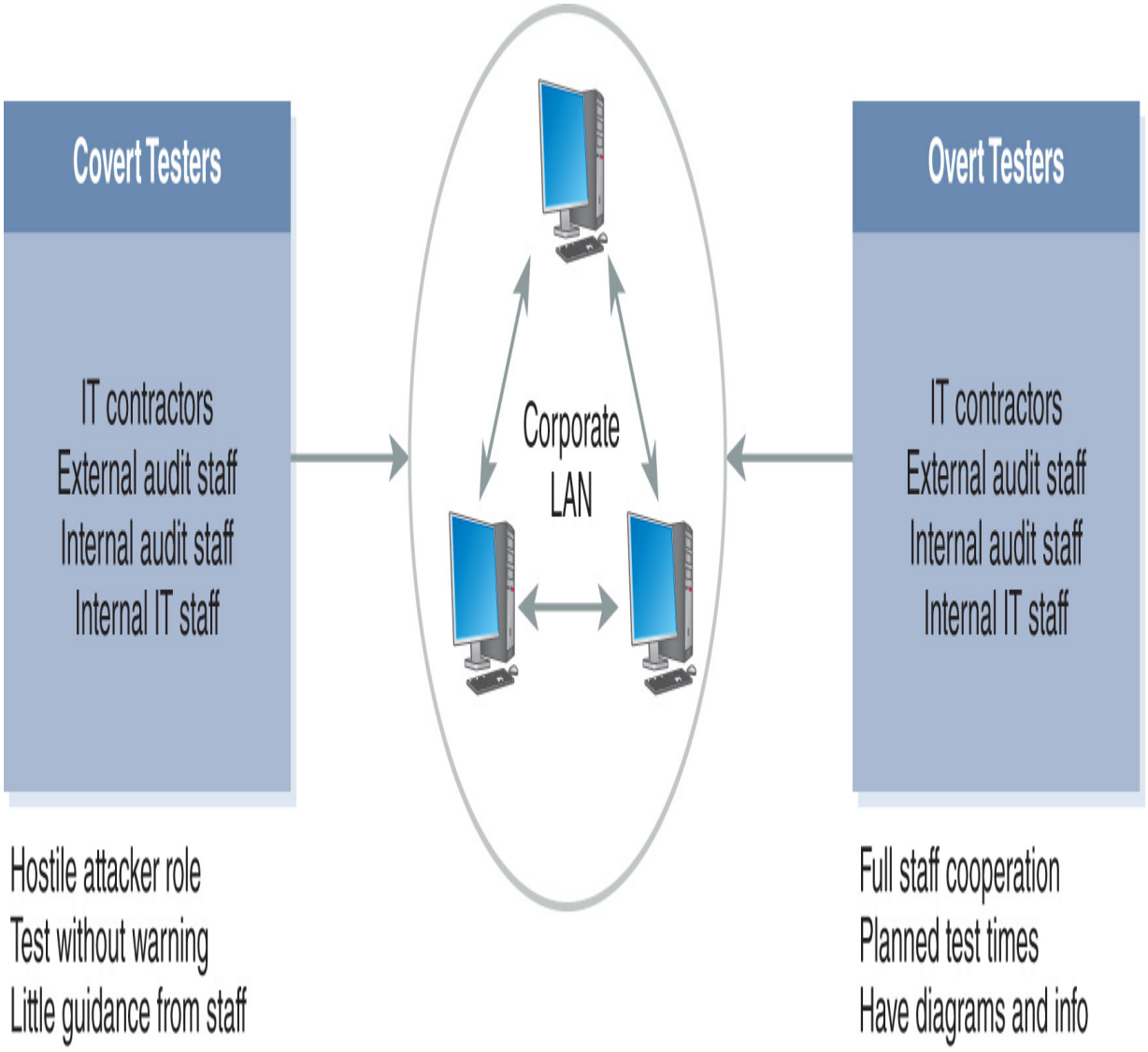


FIGURE 10-16 Covert versus overt testers.

Regardless of who does the testing, you must consider the potential impact of testing activities:

- **Be aware of the potential for harm**—Some tests might crash a system, whereas other tests will have little effect. Ensure that all potentially affected parties are aware of which tests you will conduct and that you have agreement from all parties if any tests might cause services interruptions or difficulties. Always make plans to recover if the tests—even the safe tests—crash a system.
- **Be aware of the time of day and the day of week**—Although it is tempting to test during low-volume times because it will not affect as many users, it might not be a realistic scenario. An alternative is to do more dangerous tests during off times and safer tests during high-volume hours.

Testing Methods

Black-box testing uses test methods that are not based directly on knowledge of a program's architecture or design. The term implies that either the tester does not have the source code or the details of the source code are not relevant to what is being tested. Put another way, black-box testing focuses on the externally visible behavior of the software. For example, it may be based on requirements, protocol specifications, application programming interfaces (APIs), or even attempted attacks.

In contrast, **white-box testing** is based on knowledge of the application's design and source code. In fact, white-box tests are generally derived from source code. For example, these tests might target specific constructs found in the source code or try to achieve a certain level of code coverage.

Gray-box testing lies somewhere between black-box and white-box testing. It uses limited knowledge of the program's internals. In principle, this might mean the tester knows about some parts of the source code and not others, whereas, in practice, it usually just means that the tester has access to design documents that are more detailed than specifications or requirements. For example, the tests might be based on an architecture diagram or a state-based model of the program's behavior.

Security Testing Tips and Techniques

Before starting the testing process, consider these points:

- **Choose the right tool**—Choosing tools that are best for testing a particular software depends on what is to be tested and how the test plan indicates the tests should be carried out. Keep in mind that tool functions often overlap.
- **Tools make mistakes**—You should view preliminary results with skepticism. Watch for false positives or false negatives. Tool results can vary because detection methods often are not consistent.
- **Protect the systems**—Carrying out tests at the wrong time or in the wrong way can damage systems.
- **Tests should be as real as possible**—Tests should run against production networks and systems to the degree that is possible without impairing system operations. Consider these points when attempting to make tests as real as possible:
    - To avoid impairing systems operations, first run a series of tests that are not likely to crash or have a major impact on a system. Next, fix the vulnerabilities those tests detect. Then, run tests that might interrupt normal operation during times when an interruption would have the least impact.
    - On the most critical systems, you may be able to run these tests at the same time as business continuity plan testing. For example, test at the alternate site or test at the primary site after successfully running the full interruption test but while still operating at the alternate site.
    - The tester and management will decide whether the penetration test should be limited to technical (remote) means or the tester should try to take advantage of human behavior (i.e., social engineering) to get access. Social engineering tests can be difficult to carry out but can reveal additional vulnerabilities if done well.

CHAPTER SUMMARY

In this chapter, you learned about security auditing, testing, and monitoring. You learned how auditing is used to help an organization make computing environments more secure; why these audits are necessary and how they create a culture of responsibility and accountability; and how to define an auditing plan, including its scope, and how it works to develop secure systems. You learned about auditing benchmarks and how they help to create the basis for an auditing plan and about data collection methods, including how they help in gathering information required to perform a quality audit. You studied post-audit activities and how they help in completing the process. You explored log collection and analysis, including how they help with monitoring systems. You also learned about log management and developed an understanding of the types of log information that should be captured and the tools that can help with capturing it effectively. Finally, you explored monitoring and testing security systems.

Recovery from a Disaster

The DRP does three things:

- It establishes an emergency operations center (EOC) as an alternate location from which the BCP/DRP will be coordinated and implemented.
- It names an EOC manager.
- It determines when that manager should declare an incident a disaster.

A DRP enables an organization to make critical decisions ahead of time. That way, personnel can manage and review decisions without the urgency of an actual disaster. If these plans are not ready in advance, security professionals and managers will have to make best-guess decisions under huge pressure.

DRPs are long-term, time-consuming, expensive projects, which, for a large company, can cost tens of millions of dollars. It is essential that senior management not only support but also insist upon an effective, well-tested DRP.

The process starts with a business analysis, which identifies critical functions and their maximum tolerable downtimes and then identifies strategies for dealing with a wide variety of scenarios that might trigger the plan. As a security professional, you most likely will participate as a member of the disaster-planning and disaster-recovery teams.

Activating the Disaster Recovery Plan

As a security professional, you will play a key role in reestablishing business operations in a crisis by rebuilding the networks and systems that the business requires. The recovery process involves two main phases, the first being to restore business operations. In many cases, the recovery might be at an alternate site and may require building a network rapidly from available backup data, backup equipment, and any equipment that might be available from vendors.

The second phase is to return operations to their original state before the disaster, which requires rebuilding the primary site. The transition back to the normal site and the closure of the alternate site should be part of the "Return to Home Site" portion of the BCP/DRP.

As part of the second phase, activate the salvage and repair teams. They will do their work before people and data can return to the primary site. Security professionals are often on the repair team to rebuild the damaged parts of the network infrastructure. They will match—or increase—previous security levels. If employees need new equipment, use this opportunity to improve security.

NOTE

Remember, a disaster is an event that prevents a CBF from operating for a period greater than the MTD.

Operating in a Reduced/Modified Environment

During a crisis, many of the normal conditions, such as controls, support, and processes, might not be available. Adapting quickly is necessary to ensure the secure operation of systems, including backups and reconciliation of errors. Here are a few points to keep in mind:

- You may want to suspend normal processes, such as separation of duties or spending limits. Compensate with additional controls or by additional auditing. The DRP should give added privileges or spending authority to certain people or for certain tasks.
- If a number of systems are down, users might need more technical support or guidance on how to use alternate systems or access. The BIAs should have identified minimum recovery resources as part of the recovery needs.
- During a disaster and recovery, it might be good to combine services that were on different hardware platforms onto common servers, which

might speed up recovery. However, this process must be managed carefully to make sure that the movement and recovery goes smoothly.

- While running at the alternate site, it is important to continue to make backups of data and systems, which might prevent new disasters if the recovery site fails.

NOTE

DRPs can lower insurance rates, and the preparation of a DRP can assist in risk management efforts.

Primary Steps to Disaster Recovery

The primary steps to disaster recovery (in order of importance) follow:

1. Ensure the safety of individuals.
2. Contain the damage.
3. Assess the damage and begin recovery operations according to the DCP and BCP.

Restoring Damaged Systems

There must be a plan for rebuilding damaged systems that includes where to find configuration charts, inventory lists, and backup applications and data as well as having access control lists to make sure that the system allows only legitimate users on it. The following points are important to remember:

- Once the rebuilding starts, the administrator must make sure to update the operating systems and applications with the most current patches. Backups or installation disks often contain older versions that are not current.

- After you rebuild the system, you must restore the data to the RPO, which includes reconciling books and records. You must make sure the operating systems and applications are current and secure.
- Some organizations overlook access control permissions in recovery plans. You must activate the access control rules, directories, and remote access systems to permit users to get on the new systems. When you are making the plan, be sure that any vendor software will run on alternate processors because some vendors license their products to operate on only a certain CPU.

Disaster Recovery Issues

Here is a short list of disaster recovery issues that are often overlooked in the maintenance and execution of a DRP.

- **Generators**—Ensure all fuel is fresh and contracts are in place to guarantee a supply of fuel in a crisis. Generators must receive routine maintenance and should be run periodically to make sure they are ready to operate and capable of carrying the expected system load.
- **Safety of damaged site**—You must protect the primary (damaged) site from further damage or looting.
- **Reentry**—Arrange for qualified people to examine the damaged site and determine whether it is safe for humans to reenter and occupy the space.
- **Transportation of equipment and backups**—The plan must provide safe transportation of people, equipment, and backup data to and from the alternate site.
- **Communications and networks**—Traditional and cellular telephone service and network connectivity often fail in a crisis. You might need an alternate method of communication, especially among key team members.

Recovery Alternatives

A business continuity coordinator considers each alternative's ability to support critical business functions, its operational readiness compared with

RTO, and the associated cost. This person examines specifications for workspace, security requirements, IT, and telecommunications.

Three choices are usually considered if a business (or some part of it) has to be moved for recovery:

- A dedicated site operated by the business, such as a secondary processing center
- A commercially leased facility or services, such as a hot site, mobile facility, or cloud-based virtual data center
- An agreement with an internal or external facility

External commercial providers offer services to many organizations, which means that, if there is a disaster, it could affect many customers of a commercial provider. What priority will you have if this happens? Know the options (along with prices) for things such as test time, declaration, fees, and minimum/maximum recovery days. Make sure that the specifications for workspace, security requirements, IT, and telecommunications are suitable for the CBFs. Ensure that suitable accommodations are available for staff, including facilities for resting and showering, as well as catering.

No matter what choice a business makes, the IT department's job is to make sure all necessary equipment is available at the alternate site, and this includes the critical files, documentation, and other items identified in the recovery categories. Other items can include additional patch cables, USB drives, or other common items IT personnel may use on a daily basis.

Interim or Alternate Processing Strategies

Regardless of where operations will continue, the organization will need a location to support the IT infrastructure. There are several options available, depending on cost and the time it takes to become operational. Here are the most common recovery location options:

- An alternate processing center or mirrored site is always ready and under the organization's control. It is the most expensive option because it requires fully redundant or duplicate operations and synchronized data, and the organization operates it continuously. Its additional costs

might be justified by business needs (such as having a duplicate support staff) other than recovery planning. However, making cost allocations is complex.

- A hot site is one that can take over operations quickly. It has all the equipment and data already staged at the location, though you may need to refresh or update the data. There are two kinds of hot sites: one that is company owned and dedicated and one that is commercial. The hot site's advantage is that it can provide alternative computing facilities quickly, allowing rapid recovery. An internally owned hot site will be more expensive than other alternatives, but no one else will compete for it during a regional disaster.
- A warm site has some of the common IT, communications, power, and HVAC, but you will have to arrange for the purchase and delivery of IT equipment such as servers and communications. You will have to retrieve and load data as well. Many organizations own warm sites and often use them for offsite data storage.
- A cold site is an empty data center with HVAC and power and is the least expensive option. It requires a lot of time to get up and running because you must acquire and configure all equipment and telecommunications. Some organizations begin recovery in a hot site and transfer over to a warm or cold site if the interruption lasts a long time.
- A mobile site is a trailer with necessary environmental utilities that can operate as a warm or a cold site. It is very flexible, can have a fairly short switchover time, and comes with widely varying costs based on the site's size, capacity, and readiness status.

TABLE 11-1 compares the most common recovery site options.

TABLE 11-1	Comparing common recovery site options.

FEATURE	HOT SITE	WARM SITE	COLD SITE	MOBILE SITE	MULTIPLE SITES
Cost	High	Medium	Low	Varies	No direct costs
Computer equipped	Yes	Yes	No	Yes (if warm)	Yes
Connectivity equipped	Yes	Yes	No	Yes (if warm)	Yes
Data equipped	Yes	No	No	No	Yes
Staffed	Yes	No	No	No	Yes
Typical lead time to readiness	Minutes to hours	Hours to days	Days to weeks	Hours to days	Moments to minutes

Processing Agreements

One way to solve recovery problems is to find organizations with similar IT configurations and backup technologies. This could be another company, a contingent carrier, or a service bureau. You then forge an agreement with the other organization to provide support if your company encounters a disaster. IT, security, and legal departments should carefully review draft agreements before the final agreement is signed.

Reciprocal or Mutual Aid

A company might enter into a reciprocal agreement with another company that has similar technology or into a mutual aid or consortium agreement in which a number of companies agree to support each other. A company must consider this approach carefully: Can each organization continue its primary business while supporting another? Can the equipment and infrastructure support both organizations? You must do tests to confirm that all systems can handle the extra load and that they are compatible. You also must consider the sensitivity of the data and any regulations that apply to it because the partners' administrators or users might be able to access it. And both parties must warn each other if they upgrade or retire technology that could make their systems incompatible.

Reciprocal Centers

Reciprocal centers often involve businesses that do the same type of work but are not direct competitors. These centers might include cross-town hospitals or a paperback book publisher paired with a hardcover publisher. Familiarity and commonality have advantages. These centers may share special codes, industry jargon, and special forms needed in the industry. For example, hospitals use the term "DRG code," which refers to a number that corresponds, in a common database, to a diagnosis, procedure, or disease.

Contingency

An organization might contract for contingency carriers or contingent suppliers if its primary supply method fails. With this option, you need to consider maintenance fees and activation time. As well, it is prudent to ask whether the carriers, especially communications carriers, share the same cable or routing paths.

Service Bureau

A service bureau is a service provider that has extra capacity, such as a call center to handle incoming calls, and an organization can contract for its emergency use. This option can raise the same concerns as those pertaining to a reciprocal agreement arrangement. The vendor might increase its business and consume its extra capacity or might modify its hardware or configurations.

Using the Cloud

Cloud computing has become very popular in recent years, and it is expected that more organizations will incorporate the cloud into at least some of their IT environment over the coming years. Because cloud computing is based on virtualization, it is easy to copy entire server images from place to place, which is a technique that makes maintaining disaster recovery sites much more affordable. Nearly any organization can maintain a cloud-based disaster recovery site for a fraction of the cost of a physical site.

All of the options you learned about in this chapter (except for a mobile site) are available in the cloud. Cloud-based disaster recovery sites can exist as cold, warm, or hot sites. An even less expensive option is to just back up

critical files to cloud-based storage. Of course, you must consider the time required to recover if the primary site fails.

The common virtualization snapshot feature, whereby a virtual machine (VM) image with all desired patches applied is created, is useful in disaster recovery and makes a great starting point for a recovery image. With virtualization it is possible to launch as many virtual alternate sites as necessary to support an organization's operations until its primary data center is back up and running. Cloud computing opens more recovery options by potentially lowering the cost of setting up and maintaining alternate environments. As you should do whenever you consider any change to an IT environment, evaluate how using the cloud affects security. You will still have to test all the security controls, even when using virtualization, but this new technology provides many benefits to responding to interruptions or incidents. There are more uses for virtualization than just disaster recovery; the options are plentiful, such as spinning up VM images as isolated servers, or sandboxes, if you need to conduct testing without affecting operations. However, as always, you must ensure that you are meeting or exceeding the security policy requirements, regardless of where you choose to store your data or conduct your processing.

KEY CONCEPTS AND TERMS

Anomaly-based IDS
Benchmark
Black-box testing
Clipping level
Covert act
False negative
False positive
Gray-box testing
Hardened configuration
Hardening
Log file
Network mapping
Operating system fingerprinting
Overt act
Pattern- or signature-based IDS
Penetration testing
Real-time monitoring
Reconnaissance
Security audit
Security information and event management (SIEM) system
Security orchestration, automation, and response (SOAR) system
Service Organization Control (SOC)
Stateful matching
Vulnerability testing
White-box testing

CHAPTER 10 ASSESSMENT

1. When you use a control that costs more than the risk involved, you are making a poor management decision.

   A. True

   B. False

2. Which of the following is an example of a level of permissiveness?

   A. Prudent

   B. Permissive

   C. Promiscuous

   D. Paranoid

   E. All of the above

3. An audit examines whether security controls are appropriate, installed correctly, and _____.

   A. Current

   B. Addressing their purpose

   C. Authorized

   D. Cost effective

4. A _____ is a standard used to measure how effective a system is as it relates to industry expectations.

   A. Control objective

   B. Configuration

   C. Benchmark

   D. Policy

5. Post-audit activities include which of the following?

   A. Presenting findings to management

   B. Data analysis

C. Exit interviews

D. Reviewing of auditor's findings

E. All of the above

6. Some of the tools and techniques used in security monitoring include baselines, alarms, closed-circuit TV, and honeypots.

A. True

B. False

7. _____ is used when it is not as critical to detect and respond to incidents immediately.

A. Non–real-time monitoring

B. A logical access control

C. Real-time monitoring

D. None of the above

8. A common platform for capturing and analyzing log entries is _____.

A. Anomaly-based intrusion detection system

B. Honeypot

C. Security information and event management (SIEM)

D. Pattern-based intrusion detection system

E. All of the above

9. In _____ methods, the IDS compares current traffic with activity patterns consistent with those of a known network intrusion via pattern matching and stateful matching.

A. Signature-based

B. Anomaly-based

C. Heuristic scanning

D. All of the above

10. Host isolation is the isolation of internal networks and the establishment of a(n) _____.

A. HIDS

B. DMZ

C. IDS

D. IPS

11. A hardened configuration is a system that has had unnecessary services enabled.

A. True

B. False

12. The review of the system to learn as much as possible about the organization, its systems, and networks is known as _____.

A. Penetration testing

B. Vulnerability testing

C. Network mapping

D. Reconnaissance

CHAPTER 11
Contingency Planning

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ONE CONSTANT THAT ALL ORGANIZATIONS CAN COUNT ON IS CHANGE. Managing an organization is a constant series of adjustments to changing conditions; for example, shareholders exert new pressures, governing bodies pass new legislation and set new standards, customers demand more responsiveness and flexibility. Organizations must maintain supply chains connecting their suppliers and their customers. Staying competitive means developing strategies to meet business goals even when changes or interruptions threaten to derail normal operations. Responding to these changes and challenges might require that the organization shift personnel, alter the information technology (IT) organization, and rearrange logistics. Any responses to these changes increase risk. The structure of any organization reflects its culture. Likewise, the culture affects an organization's commitment to protecting information and the people and infrastructure that support it.

The way an organization manages risk and ensures continuous operations in the face of interruptions reflects the value the organization puts on its critical assets. If a risk is not considered to be a serious threat to business operations, the organization is not likely to invest much effort in addressing it. The amount of resources an organization is willing to expend to protect sensitive data and resources affects risk. Perhaps an organization understands that a specific risk to continuous operations is important, but it simply does not have enough budget to address the risk. Or perhaps an organization has a disposable culture, seeking only short-term gains. It may choose to cease operation under adversity. If so, it will likely take only the bare minimum steps to meet required standards. If, however, an organization is committed to long-term success, it will invest in cost-effective plans to reduce risk and ensure continuity of operations. Either strategy might be a good fit for a particular organization. The only mistake is not matching risk management

spending to the company's culture. For example, a disposable organization should not invest in a sustainable plan, and vice versa.

Chapter 11 Topics

This chapter covers the following topics and concepts:

- What business continuity management is
- What critical business functions (CBFs) are
- What a business impact analysis (BIA) is
- What a business continuity plan (BCP) is and how organizations use it to make sure a disruption does not put them out of business
- What role backups play in disaster recovery
- What steps to take to respond to security incidents
- What a disaster recovery plan (DRP) does
- What the primary steps to disaster recovery are

Chapter 11 Goals

When you complete this chapter, you will be able to:

- Understand how to identify critical business functions
- Understand how to effectively respond to security incidents to limit exposure to damage
- Understand how to prevent and recover from disruptions using a business continuity plan and a disaster recovery plan

Business Continuity Management

The way an organization responds to a disruption might well determine its survival, and poor planning greatly increases the risk of failure. With poor planning, an organization will not be able to respond appropriately and may be unable to return to normal operations. Planning for disruptions is part of business continuity management (BCM), which includes both of the following:

- **Business continuity plan**—A **business continuity plan (BCP)** contains the actions needed to keep critical business processes running after a disruption. Disruptions can be minor, such as a power outage, or major, such as weather damage that makes an organization's building unusable.
- **Disaster recovery plan**—A **disaster recovery plan (DRP)** details the steps to recover from a disruption and restore the infrastructure necessary for normal business operations.

BCM includes not only BCP and DRP but also crisis management, incident response management, and risk management.

A **disruption** is a sudden unplanned event. It upsets an organization's ability to provide critical business functions and causes great damage or loss. Examples of major disruptions include the following:

- **Extreme weather**—Hurricanes Laura and Sally in 2020 are two examples of destructive weather events.
- **Criminal activity**—This might include the theft of credit card numbers or other customer data.
- **Civil unrest/terrorist acts**—Riots across the United States in 2020 caused disruptions to businesses of all types.
- **Operational**—For example, 268 million users worldwide had their Internet access shut off by government-imposed interruptions throughout 2020.

- **Application failure**—Three examples from 2020 are Microsoft Azure, Zoom, and Amazon Web Services failures. Businesses that depended on these cloud services had to find other ways to perform business operations until service was restored.
- **Pandemic**—The most recent example of a worldwide pandemic is the COVID-19 pandemic that swept throughout the world in 2020 and interrupted the operations of nearly every organization.

The purpose of BCM is to mitigate incidents and ensure continuity of operations. When an incident does occur, however, the first priority must always be to ensure the safety of people. Containing the damage is secondary.

Emerging Threats

Part of the risk identification activities when considering disruptions should address new and emerging threats. These types of threats can come from many areas and from both internal and external sources. Some examples of emerging threats include the following:

- New technology
- Changes in the culture of the organization or environment (including changes outside the organization, such as behavior changes during and after a pandemic)
- Unauthorized use of technology (e.g., wireless technologies, rogue modems, smartphones, tablets, unlicensed software)
- Changes in regulations and laws
- Changes in business practices (e.g., outsourcing and globalization). A proactive security professional watches for new threats that could interrupt business operations and thus trigger the need for a new risk review. Two of the most common areas of emerging threats are the cloud and virtualization. As organizations outsource data and processing to cloud service providers, they encounter new threats. Some threats apply to cloud service providers, and others are generally related to internal or external users of virtualization. These threats can include the following:

- Violation of virtualization barriers
- Lack of access controls for outsourced resources
- Reliability of cloud or virtualization services
- Cloud service provider (CSP) lock-in
- Insecure application program interfaces (APIs)
- Malicious insiders
- Account hijacking

Although any of these threats may occur in all environments, the risk in a cloud or virtualized environment is of greater concern due to the common practice of delegating responsibilities of these environments to external parties. Always consider new and novel threats when considering cloud or virtualized services.

Static Environments

Another class of threats bearing closer examination relates to static environments, which are types of systems that do not change very much or at all after deployment. While "normal," or dynamic, systems do change often, static systems tend to remain much like they were when first installed. Some examples of static systems include:

- **Supervisory Control and Data Acquisition (SCADA)**—SCADA systems are common in industrial settings; they control and monitor physical devices, such as manufacturing; power generation; oil, water, and gas distribution; and facility environmental controls. These systems are often built by the manufacturer with static versions of an operating system and other software to produce a fixed software stack. A SCADA system is not easy to patch when security vulnerabilities are discovered in one of its embedded software layers.
- **Embedded systems**—These systems are generally small computers that are contained in a larger device. The computer components are often enclosed in a chassis that houses the rest of the device. Such devices can include other hardware and mechanical parts. For example, a robotic vacuum device contains an embedded system that controls its

movement. The embedded computer is not easily accessible and is difficult to update with security patches.

- **Mobile devices (Android and iOS)**—Smartphone and tablet mobile operating system patches and upgrades are available and easy to apply, but not all users update their devices, sometimes because of having had bad prior upgrade experiences. Not upgrading a device can lead to vulnerabilities on unpatched mobile endpoints. In addition, many mobile devices are beyond the control of the organizations to which they connect.
- **Mainframes**—These large computers exist primarily in large organization data centers. They handle large-scale data processing and are expensive to maintain. Downtime is expensive and discouraged. For that reason, there is not much opportunity to apply security patches until a downtime window approaches. Mainframes may operate as vulnerable to emerging threats for some time.
- **Gaming consoles**—These consoles are really just computers that are optimized to handle graphics applications efficiently. Today's gaming consoles are commonly connected to the Internet and are routinely exposed to new threats. Manufacturers do provide security patches, but, because most users just want to plug in their consoles and play, they may not be diligent about keeping their systems updated.
- **Internet of Things (IoT) devices**—Individuals and organizations of all sizes are implementing a growing number of smart devices that use wireless network connectivity to provide remote sensing or control of some physical entity. Remote climate and lighting controls, motion sensitive cameras, temperature and humidity sensors, and appliances of all types are commonly offered with network connectivity options. The devices can communicate with one another to provide unparalleled sensing and remote control but can also be open avenues for attackers to infiltrate a network. Instead of carefully securing each device before connecting to a network, most users simply take the easy (and insecure) "fast start" approach of accepting manufacturer defaults.
- **Vehicle systems**—This final category of static systems is a type of embedded system. Increasing numbers of vehicles contain computing systems that monitor conditions, provide connectivity to the Internet, provide real-time routing, and even control the vehicle's operation (e.g.,

automatic parking and self-driving cars). Intervention systems to enhance safety are included in more and more new vehicles. For example, antilock braking and anticollision systems are available on many models. These systems tend to be very difficult to upgrade or patch due to the effort required to take the vehicle to a service agent who can perform maintenance. If manufacturers make the update process too easy, attackers could easily inject malicious code.

Part of the risk identification process should include these static systems because, just like other systems, they also encounter threats. Addressing threats to these types of systems may be more difficult, but a secure system depends on the security of all its components.

Terminology

Contingency planning involves several components to ensure any organization is prepared to support ongoing operations in the face of disruptions. These components include:

- **Critical business function (CBF)**—A starting point in planning for interruptions is to define each business function that is critical to an organization staying in business. If any **critical business function (CBF)** fails, normal operation ceases. Therefore, an organization's primary objective is to protect its CBFs.
- **Business impact analysis (BIA)**—A BIA is an analysis of CBFs to determine what kinds of events could interrupt normal operation. You should not limit the focus of the BIA to the information systems department and infrastructure; a business with a supply-chain disruption (e.g., warehouse fire or trucking strike) could easily suffer a major impact that has nothing to do with technology at all. Different scenarios may affect different departments, and a critical few will affect the entire business. You will learn more about BIAs later in this chapter.
- **Maximum tolerable downtime (MTD)**—MTD is the most time a business can survive without a specific CBF. A major disruption is any event that makes a CBF unavailable for longer than its MTD. Each of the disaster-planning and mitigation solutions must be able to recover CBFs within their MTDs. Systems and functions with the shortest MTDs

are often the most critical. The next section covers this topic in more detail.

- **Recovery time objective (RTO)**—RTO is the timeframe for restoring a CBF. RTO must be shorter than or equal to the MTD.
- **Recovery point objective (RPO)**—Because incidents can cause loss of data, you must calculate the amount of tolerable data loss for each CBF. Recovery procedures must be able to meet the minimums defined by the RPO. If the business can afford to lose up to one day's data, then nightly backups might be an acceptable solution. However, if the business must prevent all data loss, a more expensive data redundancy solution will be required.
- **Emergency operations center (EOC)**—The EOC is the place where the recovery team will meet and work during a disruption. Many businesses have more than one EOC: one nearby, for use in the event of a building fire, for example, and another might be a significant distance away, for use in the event of an earthquake, regional power outage, or other interruption that covers a large geographic area.

TIP

When considering how often devices may fail, there are a few other terms that you should know. Be familiar with these terms:

- **Mean time to failure (MTTF)**—Average time a device will function before it fails.
- **Mean time between failures (MTBF)**—Average time between failures (assuming that failures are repaired).
- **Mean time to repair (MTTR)**—Average time it takes to repair a device and return it to service.

NOTE

Organizations often provide fault tolerance by deploying redundant components. Some common ways to provide fault tolerance include the following:

- **Redundant Array of Inexpensive Disks (RAID)**—A RAID comprises multiple disk drives that appear as a single disk drive but actually store multiple copies of data in case a disk drive in the array fails. RAID can be deployed with different levels of redundancy.
- **Clustering**—Clustering involves connecting two or more computers to act like a single computer. If one component of a cluster fails, the other component(s) continue operating without crashing.
- **Load balancing**—With load balancing two or more servers are used to respond to service requests. When one server is busy, the other servers will respond to requests. This differs from clustering in that load-balancing servers are separate servers and do not coordinate beyond network messaging.
- **Multiple servers or devices**—A more generalized implementation of load balancing simply makes multiple servers or network devices available that can respond to the same requests for service. Thus, a failure of one device does not stop all processing because the redundant servers or devices can continue operating.
- **Outsourcing to the cloud**—The most popular fault tolerance strategy is to outsource data and functionality to cloud service providers. The SLA with service providers provides the uptime and availability guarantees in exchange for a monthly payment. Thus, the cloud service provider is responsible for determining the best fault tolerance implementations to meet the SLA availability requirements.

Here is an explanation of how MTD and RTO work together. Suppose power goes out in the data center. It takes six hours to move to the alternate site (RTO), and the business can survive for nine hours without a functioning data center. At this point, there is an event but not yet an incident that you can define as a major disruption or disaster. If you expect power to return within three hours (MTD − RTO), the business might not declare a disaster in anticipation that activity will resume normally. However, if power is still out at the three-hour mark, it is time to declare a major disruption.

In this example, the three-hour mark is a critical milestone, but suppose that the organization chose not to switch operations to the alternate site at that time and, instead, waited four hours. Because it takes six hours to switch over to the alternate site, the organization would then suffer a loss of 10 hours, an hour beyond the MTD of nine hours. Now, suppose that the data center provides services to other organizations and the service level agreements (SLAs) dictate outages no longer than nine hours, with monetary penalties for longer outages. That extra hour could cost the organization tens of thousands of dollars (or even more).

Of course, the best way to avoid ever being down longer than the MTD is to never be down in the first place. One important aspect of BCM is providing controls to avoid downtime whenever possible. IT contingency planning addresses how to handle components being out of service, but high-availability planning addresses how to keep critical components operational at all times. High-availability planning involves identifying any critical components and ensuring that their failure does not take the whole business process down. Any component that, if it fails, could interrupt business processing is called a single point of failure (SPOF), and one goal of BCM is to eliminate all critical SPOFs. For example, suppose an organization uses a single Internet service provider (ISP), which means that, if the link to the ISP fails, the organization has no Internet connectivity. One way to address this SPOF is to purchase Internet service from another ISP as well as the primary ISP. Deploying two or more components that are capable of providing the same service, called **redundancy**, helps increase an organization's ability to avoid downtime (which is also called **fault tolerance**).

Assessing Maximum Tolerable Downtime

You determine **maximum tolerable downtime (MTD)** by business requirements. MTD is closely associated with the RTOs of several integrated CBFs. For example, consider an online retailer, which depends on its website to generate revenue. The web servers depend on network services, ISP availability, and electricity. Each of these items will have its own incident-dependent RTO, but it will be associated with the MTD.

For example, if you determine that the website has an MTD of four hours, the RTO of the failed network services, ISP availability, and electricity must be less than four hours. Parts of the recovery will be able to take place in parallel, but other parts might have to be sequential. In this example, you cannot recover network services until the power company restores power. However, once the power is back on, you can work on restoring network services and ISP availability at the same time.

The RPO defines the amount of tolerable data loss and can come from the BIA or from a government mandate, for example, banking laws or regulations pertaining to pharmaceutical research data retention. **Figure 11-1** shows how to assess the MTD, RTO, and RPO.

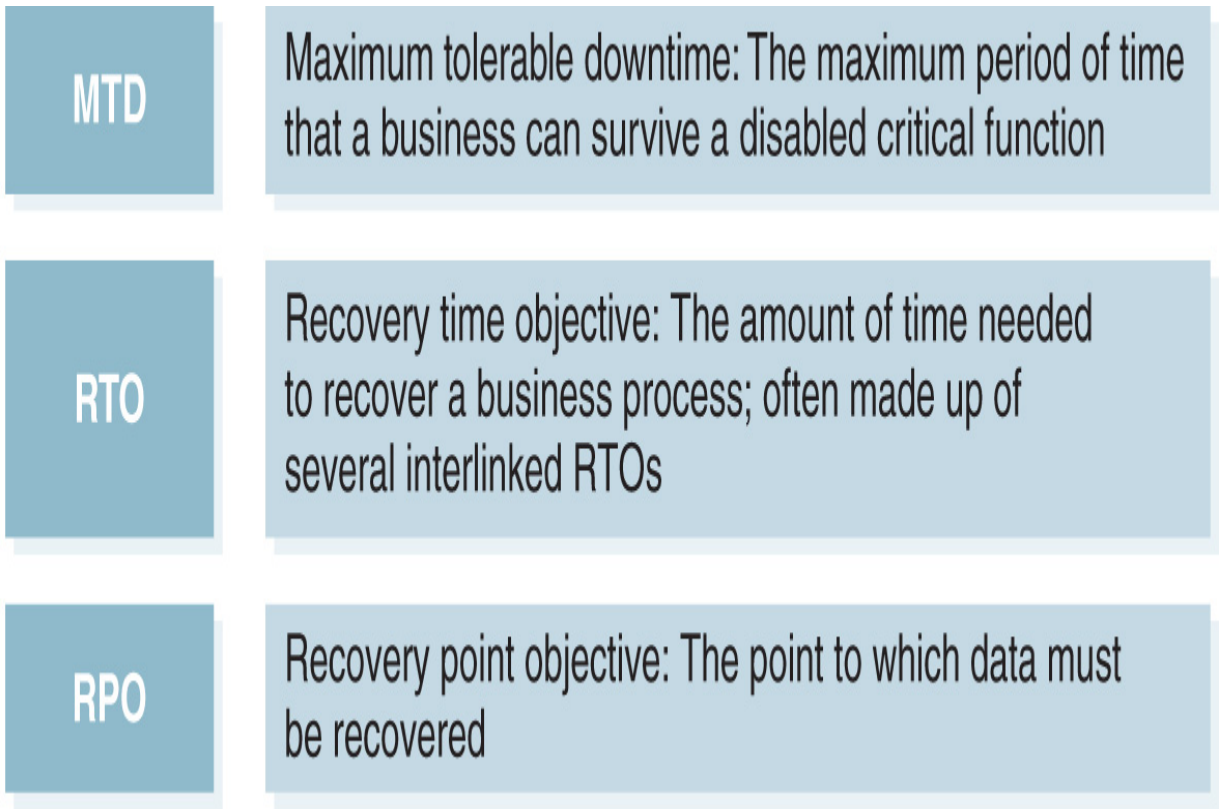
MTD
Maximum tolerable downtime: The maximum period of time that a business can survive a disabled critical function
RTO
Recovery time objective: The amount of time needed to recover a business process; often made up of several interlinked RTOs
RPO
Recovery point objective: The point to which data must be recovered

FIGURE 11-1 Assessing maximum tolerable downtime (MTD).

Business Impact Analysis

A **business impact analysis (BIA)** identifies functions that are critical to carry out business operations. After identifying CBFs, the analysis determines the extent of the impact that a particular incident would have on business operations. The BIA drives the choice of the recovery strategy and the CBFs.

As a security professional, your job is to ask three questions:

- What must we be able to carry out to stay in business?
- What can interrupt the critical business functions?
- How will CBF interruptions affect the business and its ability to protect the confidentiality, integrity, and availability of its data?

A successful BIA maps the context, the CBFs, and the processes on which they rely. You should consider all impacts, including those that are hard to address or are less obvious. Different incidents require different recovery

strategies: A fire in the accounting department might call for outsourcing and temporary quarters, a flood in the basement might activate a service bureau plan, or an earthquake or hurricane might cause a permanent move to a new facility.

You conduct a business impact analysis for three key reasons:

- To set the value of each business process or resource as it relates to how the entire organization operates
- To identify the critical needs to develop a business recovery plan
- To set the order or priority for restoring the organization's functions after a disruption

Speed of Impact

Some incidents might become more significant over time; for example, the slow deterioration of a critical processing facility might generate a disaster or the continuous installation of new devices in a computer room might overtax the electrical supply capacity and eventually cause a blackout or even a fire.

Some systems are more important during certain times of the year. For example, a company that supplies heating oil is busier in the winter so that even the smallest outage in the winter can jeopardize the company's SLAs. But that same company might easily withstand far more severe incidents (longer MTDs) in the summer, when load is minimal.

Critical Dependencies

The BIA must identify what an organization needs to support its critical operations:

- Information processing
- Personnel
- Communications
- Equipment
- Facilities
- Other organizational functions
- Vendors

- Suppliers

Assessing the Impact of Downtime

The BIA will identify critical data and systems, both of which might vary in importance. A system might be more critical than the data it contains, and vice versa. What is truly important is those systems and data on which the business relies.

Issues you should consider during the BIA fall under the following categories:

- **People**—How will you notify them of the incident and its impact? How will you evacuate, transport, and care for employees (including, for example, paying them)? Who will step in if key personnel are incapacitated or unavailable? (This is called succession planning.)
- **Systems**—What portions of the computing and telecommunications infrastructure must you duplicate immediately? How much time is available—a minute, an hour, a day?
- **Data**—What data is critical to running the business? How will you recover critical data that is lost?
- **Property**—What items are essential to the business? Things like tools, supplies, and special forms must be recoverable or easily replaced.

Assessing the impact of downtime is a planning step in the BIA; it helps to determine what must be done and in what order to accomplish the goals described in these four categories. Figuring out how to do this is the main thrust of BCM.

Plan Review

A company must update and regularly maintain the BCP, DRP, and inventory and configuration lists for the systems and applications. Some firms do this annually, whereas others choose different periods. In addition to the scheduled reviews, any major changes to the company should trigger a review. Besides the obvious benefit of having an up-to-date plan, testing and planning revisions are excellent ways to train new employees. Taking new

employees through a hands-on process teaches them the procedures and more about the environment.

Testing the Plan

You should not accept any BCP or DRP without thorough testing, which helps ensure that the plan will work and meet the CBF, MTD, RPO, and RTO objectives. Each stage of the test must consider the continued need for security and the technical resources required both to perform the test and to handle an actual disaster.

Checklist Test

A **checklist test** is a simple review of the plan by managers and the business continuity team to make sure that contact numbers are current and the plan reflects the company's priorities and structure. This kind of check is a desk check, which means that individual team members check their portion of the plan while sitting at their desks. As well as checking their contact lists, team members review whether changes in their departments affect the plan. They also look at expected changes in their departments to see whether they will trigger a need to update the plan.

Structured Walk-Through Test

A **structured walk-through test** is a tabletop exercise. During this test, a team of representatives from each department should do the following:

- Present their portion of the plan to the other teams
- Review the goals of the plan for completeness and correctness
- Affirm the scope of the plan as well as any assumptions made
- Look for overlaps and gaps
- Review the structure of the organization as well as the reporting/communications structure
- Evaluate the testing, maintenance, and training requirements
- Conduct a number of scenario-based exercises to evaluate the plan's effectiveness
- Meet to step through the plan together in a structured manner

In the case of the final step, team members should act as though they are executing the plan for a certain type of incident. The goal of the structured walk-through is to find errors in each department's plans, such as gaps or overlaps. Gaps are where one department is under the impression a critical task was to be handled by a different department. Overlaps are situations where two departments think they will have exclusive (or majority) use of the same resource; for example, two departments think they will have two-thirds of the replacement desktops.

Simulation Test

A **simulation test** is more than a paper exercise. It requires more planning than a walk-through. All the members of the staff involved in the operations/procedures participate in the test. The test identifies the following:

- Staff reaction and response times
- Inefficiencies or previously unidentified vulnerabilities

You should conduct the simulation onsite using only countermeasures defined in the plan. The simulation test involves many of the employees who have not yet participated in plan development. It is common to conduct simulations on an off day, such as a weekend.

The purpose of the simulation test is to identify shortcomings, and you should carry out the test as far as possible. If, for example, a critical file is missing, the file should be generated or obtained from the main site, and the test should then continue. Ensure that you log any on-the-spot corrections for evaluation and plan to update later. The test should end only when it is completed, or it becomes impossible to continue.

Parallel Test

Most organizations conduct **parallel tests** at an alternate site. A parallel test is the same as a full-interruption test (covered in the next section) except that processing does not stop at the primary site. Here are a few key points with respect to parallel tests:

- A parallel test is an operational test, so it will not include representatives from, for example, human resources, public relations, purchasing, and facilities.
- Because a parallel test means activating an alternate site, it will likely cost a significant amount of money. Therefore, the test must have senior management approval.
- Compare the results of the test with the processing at the original site.
- A gap analysis exposes any weaknesses or underperformance that requires attention.
- Usually, auditors are involved at every step to monitor the success and to make sure the parallel-run data is not mixed into the normal operational data.

Full-Interruption Test

The most common way to conduct this type of test is at an alternate site because it is so disruptive that few organizations conduct it at the primary site. During the test, you must shut down the original system for the duration. You can use only those processes that exist at an alternate site to continue the business operations.

WARNING

This test is high risk! Running a full-interruption test can actually create a disaster. You should run a full-interruption test only after you have successfully run all other types of tests. You must obtain senior management approval before the test.

Backing Up Data and Applications

Recovery is possible only if the company has access to reliable backups of its data and applications. Plans must include dealing with backup storage media, location, and access. Tape backup is the traditional choice for backups and still is in use today. However, restoration from tape is slow, and many systems have RTOs that are shorter than the tape-restore time. These kinds of sites often use disk-based solutions, such as a storage area network (SAN); network attached server (NAS); or even an offsite network-based storage, such as remote journaling. In remote journaling, the system writes a log of online transactions to an offsite location. The log then updates a copy of the database. Should the primary site go down, the offsite copy would be current. The availability of lower-cost solid state drives (SSDs) has made them an attractive option for some backups as well.

Backups provide extra copies of needed resources, such as data, documentation, and equipment, so that, if a primary site goes down, you can activate an alternate, or backup, site. Similarly, you can restore a backup, possibly at an alternate site, and then processing can resume.

Types of Backups

Backups and restores are slow. Businesses have three alternatives for processing them:

- **Full backup**—As its name implies, this backup copies everything to a backup media, which is usually tape but sometimes CD, DVD, or disk.
- **Differential backup**—This type of backup starts with making a full backup, perhaps on Sunday, when network traffic is lightest. Then, on Monday through Saturday, you back up changes made since Sunday's full backup on a daily basis. As the week progresses, each night's backup (the differential) takes a little longer.
- **Incremental backup**—Again, this type of backup starts with a full backup when network traffic is light. Then, each night, you back up only

that day's changes. As the week progresses, the nightly (incremental) backup takes about the same amount of time.

Backups Versus Redundancy

Redundancy, or fault-tolerance options, provides for alternate resources if a primary resource fails. In other words, a system can experience a fault but tolerate it and keep operating. However, you must know that redundancies are not replacements for backups.

For example, RAID 1 mirroring writes data to two disks instead of one. Should one disk fail, the system can continue to operate because the data is still available on the second disk. However, suppose that you have a server protected with RAID. If a catastrophic failure in the server destroys all the drives, then the data is gone, and if you do not have a backup, the data is gone forever.

Another approach would be to set up clustered servers so that standby servers take over if the primary server fails. Again, though, just because a service is using a cluster for fault tolerance, you still need backups.

It is faster to create the incremental weekday backups than the differential backups, but this comes at a price. If you need to use the backup images to restore data, systems using differential backups would need to restore only the full backup and then the latest differential. Those using incremental backups would need to restore the full backup and then each day's incremental backups to complete the restore.

You should back up items other than just data, including router, switch, and other network device configurations; user access permissions and configurations (e.g., Active Directory); and server/workstation operating systems and configurations. To make this more manageable, most large companies have a standard base configuration for workstations that can be reloaded on demand. As long as you keep these up to date (patched and fixed), this is an attractive solution.

TIP

Remember that minimizing downtime is often about avoiding downtime. Often, the simplest way to avoid downtime is to ensure that all computers and devices are patched with the latest security fixes, because patching makes systems more resistant to many types of attacks and less reliant on redundancy and other fault-tolerance techniques.

Incident Handling

As a reminder, an incident is an event that results in an actual or threatened violation of security policy. When an incident occurs, an organization needs to respond. The incident-handling process includes the following steps:

- Preparation
- Identification
- Notification
- Response
- Recovery and follow-up
- Documentation

You will learn about each of these steps in the following sections.

Preparation

The first step in an incident response program is to plan how to best respond to a variety of incidents and to build the **incident response team (IRT)**. The IRT will have the training and documentation necessary to respond to incidents as they occur. Members of the IRT should be comfortable enough with one another to communicate freely and handle each incident in a professional manner.

While organic communication should be encouraged, part of the preparation phase should be to develop a formal communication plan. An incident response communication plan spells out who should provide information and to whom during an incident. End users and management need to be informed to better understand what's going on during an incident. Even a message indicating that the IRT is working on the problem is better than silence.

The best place to start is to identify all stakeholders (anyone who may affect or be affected by an incident response plan). Keeping stakeholders satisfied is an important aspect of any project, so important that project

management best practices specify a stakeholder management plan as part of the plans needed to effectively manage projects. The stakeholder management plan contains the documentation of who the stakeholders are, why they are stakeholders, and what level of involvement each one has. While some stakeholders need constant updates, you'll need to communicate with others only when specific events occur. Planning to communicate and manage stakeholders well will reduce confusion and frustration. The quality of the planning phase determines how well the IRT can handle incidents.

Identification

The first step in actually handling an incident is to determine whether an incident has in fact taken place because not all events are incidents. Determining whether an event is an incident depends on the severity of its effects. In a manner of speaking, this is triage, or prioritizing the incident. Initial notification of an incident may come from an alarm, a complaint from a user, an alert from a security vendor, or a log analysis. Make sure you have the procedures in place to react to any type of incident.

Notification

An IRT member will often be one of the first people aware of an incident and thus must know how to react. As a first responder, it is important that this person handle the incident properly from the beginning. The goal is to contain the incident and, if possible, to improve the situation. The security professional should take care not to make the situation worse and should determine whether the event is a false positive. Be careful to make sure several false positives do not cause you to become desensitized to real events. A series of seemingly individual events taken independently might not justify a response, but, when taken collectively, they might be important.

Courts and Evidence: The Forensics Process

From time to time, an incident will be the grounds for a civil or even a criminal case. Since no one knows ahead of time which investigations will end up in court, it is important to handle all investigations with care

to make sure evidence is not tainted or made inadmissible. Always collect the most volatile data (i.e., data that may change in the near future) first. The order of volatility (and the order in which digital forensic specialists should collect the data) follows:

1. Random access memory (RAM)
2. Swap and paging files
3. Files on disk
4. Logs
5. Archived data

Even if an incident does not end up in court, the threat of court action might be enough to meet the company's needs. For example, rather than prosecuting someone, the company might choose to force a resignation.

The laws of individual countries vary, but the following is true nearly everywhere: Once evidence becomes inadmissible, it cannot be fixed. In all common-law countries (and many countries that follow civil law), evidence must be shown to be authentic; in other words, you must prove the evidence was not altered after the incident. That means specialists must capture a system image as early as possible and then conduct all analysis on the copy of the image. Doing this ensures that no one accidentally modifies the original evidence. Then, specialists can capture any network traffic and logs, along with video or other media, with appropriate time stamps. A chain of custody shows how the evidence was gathered and documented. The document lists everyone who had contact with the evidence since its discovery and shows how it was handled, what was done to it, and how it was protected from alteration.

To demonstrate that all evidence is valid and in the same condition as it was when collected, specialists can create hashes, take screenshots, and even use witnesses to the event and the collection activities. They must keep detailed records of all time and expenses used in the forensics processes. They might also need to quantify the work needed to collect the evidence. And, finally, once data collection is complete, forensics specialists can use

analysis techniques, especially emerging big data techniques, to extract useful information from all of the collected data.

> You must know how and when to escalate and whom to notify. This works well when you plan response scenarios and train IRT members.

Response

Once you identify an incident, the next phase is to limit the damage. An important aspect of this step is containment. Many incidents grow and expand rapidly, possibly affecting other systems, departments, and even business partners. The incident response plan must outline the steps that must be taken to stop the spread of the incident without causing unnecessary outage. For example, if a virus infects a system, a simple way to contain the threat is to unplug the system from the network.

It is essential to have a plan because the odds are slim of correctly guessing the best course of action in the middle of an incident. Remember, people who have the benefit of time and hindsight will evaluate your response after the incident. Thus, a preapproved response plan will lead to a better, more effective response while also providing you with blame reduction.

It is essential to identify the source and type of incident so that you can enact proper recovery procedures, because fixing symptoms does not solve problems. The responders must find out the extent of the damage and possibly recommend the initiation of the DRP if the damage is too severe. A key component of incident management is preventing future incidents. Thus, the logs and documentation gathered during the incident must be protected and available for future analysis.

Recovery

After you have contained the incident and eliminated or blocked its source, it is time to recover. Before turning the system over to its normal use, you must deal with the exploited vulnerability so that it does not happen again right

away. You might need to rebuild systems using uninfected application and data backups, or clean malicious content from the system to prevent reinfection.

Follow-Up

Learning from the incident will let management establish new procedures and controls to prevent or react to an incident more effectively in the future. Therefore, it is important to conduct a lessons-learned review of each incident to capture valuable information the IRT can use for future incidents.

Documentation and Reporting

Do not ignore the importance of documenting every step in the incident response process. The documentation you create can be very valuable to the quality of future incidents. Documenting what actions worked well and those that did not gives you an opportunity to improve the incident response plan. Over time, the collective incident response documentation can become the foundation of a valuable information resource. You can use this resource to make changes to the incident response plan and the normal security policies and procedures. For example, documenting multiple incidents related to unauthorized personnel in the data center may indicate a need for better controls. Use the information gained from documenting incident response to make the organization more secure.

CHAPTER SUMMARY

In this chapter, you learned about the reasons for and processes of business continuity management, how a business impact analysis (BIA) helps with identifying an organization's critical business functions, and how a business continuity plan (BCP) helps to ensure a disruption does not put an organization out of business. You learned how response determines an organization's ability to deal with disruptions and disasters, as well as the three types of backups and what backup models you can use to recover from a disruption. Additionally, you learned the steps to take for incident response and the role incident response plays in the risk, response, and recovery processes. Finally, you examined the main steps to disaster recovery and the roles that the security professional plays throughout the disaster recovery plan.

KEY CONCEPTS AND TERMS

Business continuity plan (BCP)
Business impact analysis (BIA)
Checklist test
Critical business function (CBF)
Disaster recovery plan (DRP)
Disruption
Fault tolerance
Incident response team (IRT)
Maximum tolerable downtime (MTD)
Parallel test
Redundancy
Simulation test
Structured walk-through test

CHAPTER 11 ASSESSMENT

1. A plan that contains the actions needed to keep critical business processes running after a disruption is called a _____.

   A. Disaster recovery plan (DRP)

   B. Business impact analysis (BIA)

   C. Business continuity plan (BCP)

   D. None of the above

2. A plan that details the steps to recover from a major disruption and restore the infrastructure necessary for normal business operations is a _____.

   A. Disaster recovery plan (DRP)

   B. Business impact analysis (BIA)

   C. Business continuity plan (BCP)

   D. None of the above

3. What term represents processes that must be operational for an organization to carry out its core business operations?

   A. CBF

   B. BCM

   C. DRP

   D. BIA

4. Which type of backup backs up only changes since the previous backup?

   A. Incremental

   B. Full

   C. Differential

   D. Redundant

5. _____ is the limit of time that a business can survive without a particular critical system.

   A. Recovery time objective (RTO)

   B. Critical business function (CBF)

   C. Maximum tolerable downtime (MTD)

   D. None of the above

6. The incident-handling process includes which of the following?

   A. Documentation

   B. Response

   C. Notification

   D. Recovery and follow-up

   E. All of the above

7. The primary steps to disaster recovery include the safety of individuals, containing the damage, assessing the damage, and beginning the recovery operations.

   A. True

   B. False

8. Which type of report includes a list of functions that are critical to an organization's operations and sets the priority for restoring those functions after a disruption?

   A. CSP

   B. BCM

   C. CBF

   D. BIA

9. What type of document includes uptime and availability guarantees for cloud service providers?

   A. Reciprocal agreement

   B. Service level agreement

   C. Processing agreement

D. Cloud performance agreement

10. Which type of disaster recovery plan test activates an alternate site but does not stop processing at the primary site?

A. Structured walk-through

B. Simulation

C. Parallel

D. Full interruption

Recovering Data

Much of the evidence a forensic investigator collects is stored as digital files on storage media. The general process of engaging in investigative activities to find and recover digital data for evidence is called **e-discovery**, or electronic discovery. E-discovery is an iterative process of examining storage media, searching for items of interest, identifying likely items that may have value as evidence, and then recovering those items. While some data may remain intact and readily visible to common tools, some data may have been deliberately deleted or be stored on damaged media. Part of a digital forensic investigator's activities involves identifying and recovering data that is not easily accessible, for which the common term is **data recovery**. In this section, you will learn about how operating systems manage file deletions, how to recover deleted files, and how to recover data from damaged media.

Undeleting Data

Many novice computer users think that deleting a file means that any data in that file ceases to exist. Fortunately for investigators, some cybercriminals are under this misconception as well. The reality is that operating systems do not remove data when a file is deleted. Computing systems delete or replace data with such frequency that going to the trouble of removing any old data would result in a high performance penalty. To keep computing systems running efficiently, file deletions are noted in the file's header. Each file system handles the specifics differently, but the most common method of deleting a file is to simply mark the file as "deleted" and leave any data that file contained untouched. The sectors of a disk that contain data from a deleted file are put on a queue of available sectors, which means the data will eventually be overwritten when another file needs the space. But, if you can get to the sectors before they are reused, you can recover deleted data.

There are two keys to successfully recovering deleted data. The first key is to try to limit disk activity, which can be done by stopping as many processes as possible that may write data to the disk. The key is to stop any

process from requesting new sectors to store data. Because doing that can be tricky, the best choice is to grab an image of memory and then stop the computer or device. Once the device or computer has been shut down, its persistent storage device (i.e., disk drives) can be attached to a forensic lab device and data read without worrying about overwriting any deleted data. In a general sense, Windows operating systems make things a bit easier to recover deleted data because the file systems Windows uses, mainly FAT32 and NTFS, have relatively stable file structures that make file recovery fairly straightforward with the appropriate utility software.

Some popular file recovery utilities for Windows include DiskDigger (*https://diskdigger.org/*), WinUndelete (*www.winundelete.com/*), FreeUndelete (*www.officerecovery.com/freeundelete/*), and OSForensics.

UNIX/Linux computers and devices are a little more dynamic, at least with respect to the way in which files get stored. Thus, stopping active processes is more important for UNIX/Linux devices to avoid sector reuse for deleted files.

As with Windows computers, there are multiple options for recovering deleted data from UNIX/Linux computers and devices. Popular options include extundelete (*http://extundelete.sourceforge.net/*), TestDisk (*www.cgsecurity.org/wiki/TestDisk_Download*), the Ultimate Boot CD (*www.ultimatebootcd.com/*), and R-Linux (*www.r-studio.com/free-linux-recovery/Download.shtml*).

Although macOS shares its roots with Linux, it is a fundamentally different operating system, even though many Linux commands and programs may run in macOS. If you encounter a macOS computer, you can explore the software already mentioned for Linux as well as look at MacKeeper (*www.data-retrieval.net/osx/mackeeper-files-recovery.html*), which is a deleted file recovery tool tailored for computers running macOS.

Recovering Data from Damaged Media

Some storage media you encounter might contain data you cannot access that is not due to an attacker's deliberately attempting to delete it. In other cases, you will be faced with extracting valuable evidence from storage media or file systems that have been damaged, such as CDs and DVDs that have been physically damaged from heat or have been cracked or scratched or magnetic

hard disks damaged from magnetic exposure or that have suffered head or motor damage or even controller failure. Even if the physical device is operating well, there could be logical damage, which refers to situations in which the physical media is fine but low-level formatting data is damaged or some error caused the media to report one or more sectors as being bad.

Regardless of the reason the media is damaged, some or even all of the data stored on the device may still be extractable. In the case of physical damage, you may be able to fix enough of the problem to recover the data, but, even if you cannot fix the problem, it may be possible to read around the damaged part of the media and get most of the data. Here is a list of troubleshooting steps when you encounter physical media damage:

1. Remove the media and install in a test system. Doing this would show whether the original system was the problem.
2. Boot the test system and listen to the damaged media to see whether it makes any noise. You should hear normal sounds as the system boots. For disk drives, you should hear spinning and initial access sounds.
3. If you hear normal sounds on boot, accessing the drive and its contents from the test system may be possible. If so, immediately scan the device for malware.
4. If you hear no sounds or abnormal sounds on boot, limited repairs may be possible. In most cases, storage media repair requires specialized equipment and skills.
5. If nothing else works, the best next step is to send the device to an organization that specializes in data recovery from damaged devices.

If the device is physically sound but data still cannot be accessed, the next step is to explore logical damage recovery. There are several software solutions that help investigators recover data from devices with logical damage, examples of which include the Sleuth Kit (*www.sleuthkit.org/*), TestDisk (*www.cgsecurity.org/wiki/TestDisk*), and R-Linux (*www.r-studio.com/free-linux-recovery/Download.shtml*). For a more comprehensive list, search for “rescue disk” on the Internet.

Chapter 12
Digital Forensics

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DESPITE THE BEST DEFENSES, SOME CYBERATTACKS MAY SUCCEEED. When faced with the results of a successful attack, cybersecurity professionals must know how to respond to protect the information technology (IT) infrastructure from future attacks. Successful attacks not only leave a trail of damage but also artifacts of what happened, commonly called **evidence**, that can be used to examine what happened, how it happened, and possibly even who carried out the attack. Digital forensics focuses on the use of technology to investigate the facts leading up to and surrounding computer security incidents. Any computer incident requires forensic specialists who know how to find and analyze evidence related to computing devices to establish what happened during an attack.

This chapter covers what digital forensics is, what types of computer crimes threaten today's IT environments, the challenges of digital forensics, and common forensic methods. You will learn about the tools and techniques that digital forensic specialists use to carry out a forensic investigation and about collecting and managing evidence for Windows, Linux, macOS, and mobile devices and how to organize forensic activities into an incident response process.

Chapter 12 Topics

This chapter covers the following topics and concepts:

- What digital forensics is
- What types of computer crime threaten IT
- How to use forensic methods and build a lab
- How to collect and handle evidence
- How to recover data

- What operating system forensics is
- How to examine mobile devices for evidence

Chapter 12 Goals

When you complete this chapter, you will be able to:

- Understand the principles of digital forensics
- Understand how to respond to and investigate incidents
- Understand how to identify and collect evidence for analysis and potential legal proceedings

Introduction to Digital Forensics

Determining what happened during a security incident is important for several reasons. First, you need to determine what really happened and the extent of any damage. Any time you suspect that a security policy has been violated, you must determine the scope of the violation. A series of failed logon attempts is very different from a critical database being downloaded by an attacker and then destroyed. You discover the extent of an attack and its damage by examining markers of activity, often referred to as evidence, related to the suspected incident. Collecting evidence is critical to understanding what happened and how much damage may have occurred.

Second, you should attempt to determine who is responsible for the incident. All incidents are the result of some activity, which could be accidental, unintentional, or intentionally malicious. For intentionally malicious activity, determining the identity of the activity initiator is important to both discourage further incidents and potentially pursue remedy for damages. In many cases, seeking remedy means initiating a legal action, such as filing criminal charges and/or initiating a civil lawsuit. Any incident that ends up becoming a legal action relies on evidence to prove any claims.

The last reason for collecting evidence is the natural continuation of the second reason. For any complainant to succeed in a court of law, that complainant must provide sufficient evidence to justify claims of damage. Evidence provides the justification for a court to agree with the complainant regarding the facts of the case and a basis for a finding to grant relief. In short, evidence is required to have any chance of success in a court of law.

The preceding reasons for determining what happened during a security incident leads to the need to formally approach investigating security incidents. A formal approach to investigation results in higher quality and more comprehensive evidence to analyze. Organizations routinely incorporate formal investigation techniques to better understand incidents that threaten their IT infrastructure and the critical data it houses. Law enforcement bases its investigations on the science of forensics. **Forensics** is the process of using science to collect, analyze, and describe evidence in a

manner that is acceptable by a court of law. IT professionals have adopted the foundations of forensics to create the field of **digital forensics**, or computer forensics, as it is sometimes called. Digital forensics is the process of using well-defined analytical and investigative techniques to guide the processes of collecting and examining evidence related to a computer security incident.

Digital forensics uses well-documented formal procedures that all involved parties can verify. The verification property of properly collected and handled evidence provides the transparency to the court that enables it to examine and accept evidence when deciding outcomes.

Understanding Digital Forensics

Although digital forensics is based on the general field of forensic science, it is a specialized faction of the more general domain but is still based on sound scientific methods and principles, not popular practices, fads, or even personal preferences. Digital forensics is based on logical methods that are repeatable and verifiable. Moreover, every step of the digital forensics process builds on a previous step and includes verifiable evidence that documents the transition from the previous state to the current state. This formal process ensures that all evidence is in the same state, or condition, it was in when it was collected and that it can be trusted. This trust in the original state is necessary for subsequent analysis or court proceedings to be able to use the evidence to draw a conclusion.

Digital forensics focuses on finding, collecting, and handling evidence, which comes in different forms. Understanding each type helps to keep evidence pristine and useful. Here are the main types of evidence you may encounter during a forensic investigation:

- **Real evidence**—Any physical object that you can touch or otherwise directly observe. Examples of real evidence include a smartphone, a laptop, a hard drive, or a USB drive.
- **Documentary evidence**—Data expressed in written form, whether on paper or stored in digital files. Documentary evidence includes data that is stored in a computer's memory as well as on storage devices as in files. Examples include email messages, databases, log and activity

files, digital media, and communication activity records. Documentary evidence must be accompanied by documentation that validates the evidence's authenticity.

- **Testimonial evidence**—Information collected from individuals that supports and helps to interpret real or documentary evidence. For example, an access control log file may indicate that a specific user placed suspicious files or photographs on a desktop, or people could state that they observed the physical presence of other people at a specific place and time to support physical access control logs.
- **Demonstrative evidence**—Any information that helps explain other evidence. Many types of evidence collected in a digital forensic investigation is technical in nature. While forensic specialists and other subject matter experts (SMEs) may not need clarification, nonspecialists often require additional explanations to understand technical evidence. Demonstrative evidence can be visual aids, such as charts and graphs, that explain complex data to a judge or jury in a legal proceeding. Another example could be an expert witness's interpretation of an incident or any conclusions drawn based on evidence collected. Demonstrative evidence is often the most important evidence in court because it provides relevance for other types of evidence. Without demonstrative evidence, other types of evidence might not be understood.

The main purpose of digital forensics is to identify, collect, and analyze evidence that documents and explains what happened during a computer security incident. Each step is important and builds on the previous step. The key is to leave no unimportant stone unturned and use the evidence found to paint a clear picture of what really happened.

Knowledge That Is Needed for Forensic Analysis

Understanding evidence is only one skill a digital forensic specialist needs. The specialist must also have in-depth knowledge of how computing systems create and accumulate information that may become evidence as well as needing to know how to interpret and understand the meaning of any evidence collected. That means specialists must be computer systems SMEs. They do

not need to know everything, but they should be comfortable with computing environments in general and have in-depth knowledge of several specialty areas. For larger environments, it is common for a forensics team to be made up of several members, with each one possessing expertise in different areas. There may be one team member who is a networking expert while another is a Linux expert. The forensics team should have expertise in all computing areas, and it is okay if that expertise is provided by different individuals.

Forensic analysis is the process of understanding and then explaining the meaning of evidence. While there is no definitive list of digital forensics expertise areas, the forensics team should have in-depth knowledge at least in these areas:

- **Hardware**—All computer instructions are carried out by, and some data eventually gets stored on, a physical hardware device. Hardware will always be part of an investigation, whether directly or indirectly. Therefore, a solid understanding is necessary of how memory, processors, interfaces, and peripherals work together to input, process, output, and store data. A deep knowledge of hardware and how it handles data is invaluable in searching for and interpreting meaningful evidence.
- **Computer memory**—Memory is often a target for attacks, both as a primary goal and as a way to cover tracks and corrupt evidence. A forensic analyst must understand how registers, **cache**, random access memory (RAM), and read only memory (ROM) work and how each one contributes to running processes.
- **Storage devices**—Some data gets written to persistent devices to store data between process invocations. Persistent data storage can provide a great source of evidence if you know where to look and what to look for. A deep understanding of how data is logically and physically stored on storage devices is another critical type of knowledge that is useful in digital forensics.
- **Operating systems**—The global software community largely consists of programs that execute in a distinct environment called an operating system. While some special-purpose programs run directly on the hardware, most processes you will encounter execute within an operating system that provides an interface to the underlying hardware.

Although there are many operating systems in use today, you will most likely encounter the five most popular operating systems: Windows, Linux, macOS, iOS, and Android. Most forensic analysts know one or two operating systems very well and a few more at an intermediate level.

- **File systems**—Regardless of the operating system in use, processes typically interface with file systems to store data on storage devices. The most common file systems are FAT32 and NTFS for Windows, Ext3 and Ext4 for Linux, and APFS for macOS. A forensic analyst should understand file systems, how they store data, and the nuances related to timing and identity of who stored what and when.
- **Networks**—Another crucial area of knowledge for forensic analysts is how networks work. More than just understanding what a network does, an effective forensic analyst understands how to collect and analyze network traffic, decomposing it into meaningful information to help tell the story of what happened. That means the analyst should have a very good understanding of networking protocols and techniques for tracing communications across a network. Networking forensics is a specialization area within digital forensics. Not every digital forensic analyst needs to be a networking specialist, but each forensics team needs at least one networking SME.
- **Software**—Application software provides the most common interface between the end user and any data that an enterprise processes and stores. Application software is often an attack target because it can allow attackers access to data and resources they would not otherwise be able to access. Some of the forensics team members should be experts in the major software products the organization uses. Understanding the Oracle or SQL Server RDBMS (relational database management system) could help track down evidence of a large-scale data exfiltration or modification if the organization uses either of those database systems. Understanding the software used is crucial to finding the right evidence to document an attack on that software.

Forensic analysis is often similar to putting a puzzle together. Sometimes you do not have all the pieces, but you still have to tell the story. An experienced

forensic analyst can take a body of collected evidence and use knowledge and experience to tell the story of what happened.

Overview of Computer Crime

Many people talk of computer crime as if it were a completely different way to carry out crime. The reality is that computer crime is just regular old crime with a few new tools. In fact, most "regular" crime today involves computers at some level. The term *computer crime* typically refers to crimes that target computer resources, either data that computers store or the services they provide (or both). Most computer criminals, whom we generally call attackers, want to disrupt normal operations or steal valuable data, and, in some cases, they want to do both. One of the first activities of a forensic analyst is to determine the type of computer crime that has been carried out, an often difficult task because the motive is not always clear. In addition to the motive being unclear, the actual target of any attack is not always clear, which is why digital forensics is sometimes viewed as an art that is based on science.

Computer crime is more of a means as opposed to a new form of crime. Criminals have not really changed much throughout the years—they've just changed their tactics. Understanding computer criminals, often called cybercriminals, is little more than understanding criminals in general and the newer tools they use to carry out crimes. Digital forensic analysts can make a difference in investigating crime because computing devices play such a large role in today's criminal activity. In most cases, computing devices play at least one of three roles in the crime:

- **Target**—One or more computing devices (e.g., servers, workstations, and networking devices) may be the attacker's target to change, infect, or otherwise make unavailable. Attackers commonly extract data from their targets or make those targets unable to carry out their intended purpose.
- **Instrument**—A computing device may not be the target of an attack but may be a party to the attack. Attackers often use a compromised computer or device to launch attacks on third parties to hide the true origin of the attack. Distributed denial of service (DDoS) attacks use

compromised devices, called bots, to carry out attacks on behalf of the true attacker.

- **Repository**—Another role a computing device may play in a crime is that of a data repository. A computing device in an IT environment may be a convenient place to store information about an attack. Attackers must keep track of their activities to carry out follow-on attacks and, in some cases, to complete attack activities. For example, ransomware attacks promise to decrypt all encrypted files after a ransom is paid. Most ransomware uses a local manifest or unique file extension to record the files it encrypted. However, it is possible that advanced ransomware could use a separate compromised device to store a list of encrypted files.

Regardless of the role computing devices play in the commission of a crime, the digital forensic analyst plays an integral role in determining what happened, who is responsible, and how to protect an environment from further similar attacks. It is this third goal that provides the greatest value. While it is important to catch the "bad guys," it is even more important to thwart any future attacks, and that is the greatest value that digital forensics provides to any organization.

Types of Computer Crime

There are many ways cybercriminals can involve computers in crimes. The criminals' motivations drive what types of crimes they attempt to carry out. When thinking about any type of cybercrime, remember that cybercriminals launch attacks to achieve specific goals and that those goals are not materially different from noncomputer crimes. Cybercriminals essentially want to generate revenue, exact revenge, make a social statement, and/or stake a reputation claim. Keeping these motivations in mind helps to understand the cybercriminal and the resulting crimes. Although there is an endless list of variations of cybercrimes, **TABLE 12-1** lists the most common types of cybercrimes you are likely to encounter.

TABLE 12-1	Common types of computer crimes.

TYPE OF COMPUTER CRIME	DESCRIPTION
Identity theft	Cybercriminals attack different websites or databases to find identifying information for individuals. Once they can find information such as Social Security numbers, names, birthdates, email addresses, physical addresses, and any other identifying characteristics, they can sell it to other criminals. Criminals of all types can use the credentials to impersonate others to take out loans; submit charges on credit cards; and even request ID cards to use for voting, benefits claims, and financial transactions.
Exfiltrating data	One of the first steps in carrying out identity theft or enabling others to engage in identity theft is to capture identifying data, and one of the most productive ways do to this is to hack into a computer that stores data for many individuals and download (exfiltrate) the personal data. Once exfiltrated, the personal data can be leveraged or sold to other cybercriminals.
Cyberstalking/ harassment	The art of using online media and assets to harass individuals is still evolving. In spite of its nascent existence, many victims have suffered from cyberbullies either threatening to soil an individual's online reputation or actually following through with attacks with the intent of ruining another person. Cyberstalking is far more than an online nuisance. People have reacted in extreme manners to online bullies, including online retaliation, real-world violence, and even suicide. Cyberstalking and cyberbullying result in real-life consequences. Therefore, laws to confront cyberbullies save lives.
Online fraud	Fraud crimes focus on extracting revenue from victims. To carry out fraud crimes, cybercriminals engage in a wide variety of activities to either impersonate victims or to convince victims to carry out transactions that benefit the criminals. Regardless of the tactics used, cybercriminals use the victim's assets for their own gains, to the detriment of the victim. In other words, cybercriminals always reduce their victims' position to enhance their own.
Nonaccess computer crimes	Some computer crimes do not depend on penetrating any access controls. A cybercriminal who succeeds at crashing a target's critical functionality or otherwise stopping normal business from occurring can successfully interrupt normal (revenue-creating) processes from occurring or create a disruptive break. Stopping revenue-generating functions is punitive. If you can stop an organization from making money you've made a point.
Cyberterrorism	The last common type of cybercrime is that of cyberspace terrorism. Cybercrime statistics from most sources are indicating an increase in cybercrime that targets government and state actor targets. In recent history, many of the world's leading nations have been involved directly in operations to either deflect other nations' attacks or to offensively launch attacks on other entities. Regardless of the intent and origin, nation-state cyberattacks are the most pervasive and well-funded of all types of cybercrime.

NOTE

The contents of **Table 12-1** do not represent an exhaustive list, and some actions may span types of cybercrime. What the contents do provide is a suggested list of crime categories. It is more important to understand the criminals' motivations than to force any action into a distinct category.

The Impact of Computer Crime on Forensics

The nature of the computer crime attempted (or carried out) affects how a digital forensic specialist responds. For example, a denial of service (DoS) attack would result in a different response from that for a cyberbullying attack. The digital forensic specialist must understand each type of attack and the unique types of evidence each one leaves behind. Understanding the specific type of evidence associated with various attacks separates the forensic novices from the veterans.

There is no definitive guide for categorizing evidence. Many of the activities related to identifying, gathering, and processing evidence relate to the experience of the individual handling the evidence. While it is theoretically possible to create comprehensive evidence-handling processes, it is more common to find experienced investigators who have learned how to handle evidence properly. There is no real-life replacement for solid experience. Relying on experience almost always results in findings that stand up in a court of law as well as being valuable to any investigation.

Forensic Methods and Labs

A forensic investigation, just like any project, can be carried out in a variety of ways. Each investigator may have different ideas on organizing activities, finding and collecting evidence, documenting tasks, and drawing conclusions. While using different approaches to investigations is not inherently bad, each organization should develop standard operating procedures for its investigations. When all investigators are operating with the same policies and procedures, teams will be able to work together more effectively. Choosing a forensic methodology gives a team a framework for conducting investigations and creating the deliverables to communicate findings. In this section, you will learn about a few approaches to forensic investigations and how to move to the next step of setting up a digital forensic lab.

Forensic Methodologies

Having a framework in place for approaching digital forensic investigations is an important step in preparing a forensics team. You will learn about some formal frameworks, but there are also some common principles you should consider. Regardless of the framework an organization adopts, here are some principles of effective digital forensic investigations:

- **Minimize original data handling**—Touch original data only to collect it and then only to create a verifiable copy for analysis. Make every effort to ensure all evidence is pristine and in the same condition as it was when it was collected.
- **Enforce the rules of evidence**—Always ensure that evidence is collected, handled, stored, and presented according to strict requirements necessary for admissibility. You will learn how to protect evidence later in this chapter.
- **Do not exceed your knowledge**—Do not engage in any activities that you are not prepared to carry out. If you are not comfortable with a device or software, do not try to learn as you collect evidence. Know

your limits and be willing to say no if you are not prepared because you might risk contaminating or even destroying valuable evidence. Learn from an expert before you go it alone.

- **Develop an analysis plan first**—Have a plan of attack before starting any investigation. The team should agree on a general analysis plan as part of team training. Then, tailor the specifics to each new investigation and follow the plan instead of making it up as you go.
- **Consider data volatility**—Remember that some data, such as registers, cache, and RAM, change frequently and become unavailable when the device is shut down. Ensure that the most volatile data is collected first before it changes or goes away. Follow the **order of volatility** to prioritize the most volatile data first before collecting less volatile data.

Digital forensic frameworks do not have to be built from scratch because there are several sets of formal guidelines that already exist. The digital forensics team-building process should include reviewing existing frameworks and adopting one or more of them. Here are some of the most popular forensic standards and frameworks:

- **U.S. Department of Defense Forensic Standards**—The U.S. Department of Defense (DoD) Cyber Crime Center (DC3) sets standards for digital evidence processing, analysis, and diagnostics as well as being involved in criminal law enforcement forensics and counterintelligence and assisting with many types of investigations. DC3 partners with government, academic, and private industry computer security officials. For more information on DC3, see *www.dc3.mil*.
- **The Digital Forensic Research Workshop Framework**—The Digital Forensic Research Workshop (DFRWS) is a nonprofit volunteer organization whose goal is to enhance the sharing of knowledge and ideas about digital forensics research. DFRWS developed a framework in 2001 for digital investigation that consists of a matrix with six classes: Identification, Preservation, Collection, Examination, Analysis, and Presentation. To find a paper that describes the framework, see *https://dfrws.org/wp-content/uploads/2019/06/2004_USA_pres-an_event-based_digital_forensic_investigation_framework.pdf*, and, for more information on DFRWS, see *https://dfrws.org/*.

- **The Scientific Working Group on Digital Evidence Framework**—The Scientific Working Group on Digital Evidence (SWGDE) promotes a framework process that includes four stages: Collect, Preserve, Examine, and Transfer. The final step means any sort of transfer, including moving evidence from the lab to a court or even returning evidence when no longer needed. For more information on SWGDE, see *www.swgde.org*.
- **An Event-Based Digital Forensic Investigation Framework**—To introduce a model that is more intuitive and flexible than DFRWS, researchers at the Center for Education and Research in Information Assurance and Security (CERIAS) at Purdue University proposed a new model that has five primary phases, each of which may contain additional subphases. The primary phases are the Readiness phase, the Deployment phase, the Physical Crime Scene Investigation phase, the Digital Crime Scene Investigation phase, and the Presentation phase. The Readiness phase contains the Operations Readiness subphase, which involves training people and testing investigation tools, and the Infrastructure Readiness subphase, which involves configuring the equipment. The Deployment phase includes the Detection and Notification subphase, in which someone detects an incident and alerts investigators, and the Confirmation and Authorization subphase, in which investigators receive authorization to conduct the investigation. For more information on the CERIAS model, see *https://dfrws.org/wp-content/uploads/2019/06/2004_USA_paper-an_event-based_digital_forensic_investigation_framework.pdf*.

Remember that a framework is just the starting point for the investigation plans, policies, and procedures. The best structure for any organized digital forensics team is one that follows industry best practices and is customized for that organization's strengths and requirements.

Setting Up a Forensic Lab

It is not difficult to set up a forensic lab, but it can become expensive as you increase the lab's capabilities. The most economical and flexible approach is to start with a laptop that meets the team's needs. The most important characteristics are the ability to attach to and interact with any devices that

may be encountered and then to store all the evidence collected. You can purchase laptop computers with common physical interface support, such as USB, internal Small Computer System Interface (SCSI), Enhanced Integrated Drive Electronics (EIDE), and Serial Advanced Technology Attachment (SATA) drives and devices. The lab should also have power connectors for all types of smartphones, laptops, routers, and other devices. To store the digital evidence collected, the lab also needs plenty of disk (persistent storage) space that is protected through redundancy and frequent backups. Evidence will be stored at least until the investigation reaches a conclusion, and often long after that. Protect all evidence from inadvertent or malicious damage by carefully securing all components of the lab.

Once you've acquired the hardware, you can focus on your lab's software. There are many options for digital forensic software. Some software is free and open source, while other popular options are paid through a license fee or subscription. A comprehensive coverage of digital forensic software is beyond the scope of this chapter, but here is an introductory list of software products to consider when building a digital forensic lab:

- **dd**—One of the most used utilities for creating forensic copies of data is the UNIX/Linux dd command-line utility. The dd command is included on most UNIX/Linux distributions and is also available for Windows computers.
- **memdump**—Another UNIX/Linux command-line utility that is included with many UNIX/Linux distributions is memdump. The memdump utility exports the current contents of a computer or device's memory to a file for analysis.
- **WinHex**—WinHex is a useful Windows hexadecimal editor program from X-Ways Software that allows the user to inspect and edit any file. WinHex is the core of the larger and more comprehensive forensic software package, X-Ways. You can find more information about WinHex and X-Ways at *www.winhex.com/winhex/*.
- **EnCase**—EnCase from OpenText, formally Guidance Software, is a popular commercial digital forensic investigation management package. EnCase provides the software to identify, collect, analyze, and manage evidence as well as managing the tasks of an investigation. You can find

more information about EnCase at *https://security.opentext.com/encase-forensic*.

- **Forensic Toolkit**—The Forensic Toolkit (FTK) from AccessData is another widely used forensic analysis tool that is very popular with law enforcement. AccessData also provides a free software tool, FTK Imager, that is used to examine and create forensic images of evidence. You can find more information about FTK at *https://accessdata.com/products-services/forensic-toolkit-ftk*.
- **OSForensics**—OSForensics from Passmark is a relatively new digital forensic suite of software that is popular due to its wide range of functionality and lower cost than many of its competitors. You can find more information about OSForensics at *www.osforensics.com/*.
- **Kali Linux**—Kali Linux is an open source distribution of the Linux operating system that is a favorite of penetration testers. Although Kali was built for penetration testing and ethical hacking, it comes with a wide range of tools that are useful to a digital forensic investigator. You can find more information about Kali Linux at *www.kali.org/*.
- **Helix**—Helix is a customized Linux Live CD used for computer forensics that is robust and full of features but simply has not become as popular as FTK and EnCase. You can find more information about Helix at *www.e-fense.com/products.php*.
- **AnaDisk Disk Analysis Tool**—The AnaDisk software from New Technologies Incorporated (NTI) focuses on floppy disk analysis and data recovery. NTI also offers the CopyQM software that handles floppy disk duplication for nonstandard disk formats. You can find more information on AnaDisk at *www.forensics-intl.com/anadisk.html* and CopyQM at *www.forensics-intl.com/copyqm.html*.
- **The Sleuth Kit**—The Sleuth Kit is a collection of command-line tools that are available as a free download. This toolset is not as rich nor as easy to use as EnCase, FTK, or OSForensics, but it can be a good option for a budget-conscious organization. A graphical user interface (GUI) has been created for Sleuth Kit, named Autopsy, that makes the Sleuth Kit's command-line tools more accessible. You can find more information on the Sleuth Kit and Autopsy at *www.sleuthkit.org/*.

- **Eric Zimmerman Tools**—EZ Tools is a set of command-line, open source tools for Windows only and developed by former FBI Agent Eric Zimmerman. Like OSForensics, EZ Tools provides a wide range of functionality but is primarily used for searching, extracting, and exporting evidence.
- **Kroll Artifact Parser and Extractor (KAPE)**—KAPE focuses on system triage and evidence searching in target storage. A common scenario for KAPE use is investigators' searching for additional leads or building timelines.

The best place to start building a forensic lab is to ask other digital forensic investigators for their opinion. Most of the software options listed in this section allow a trial period, during which you can evaluate the software before purchasing it. Try out different software to see what best fits the particular situation because there is no best software for every situation. Choosing the best hardware and software for a forensics team requires considering the requirements, the budget, and the team's skills and preferences.

Collecting, Seizing, and Protecting Evidence

Evidence serves several important purposes during the course of a forensic investigation. It can provide clues to help investigators determine what happened during an incident and can provide the basis for assigning liability or guilt in a court of law. Any time evidence is destined for a court of law, it must first be subjected to rigorous standards to ensure it is pertinent and in its original state.

The Importance of Proper Evidence Handling

Evidence is useful only when it provides compelling documentation of events that occurred in the past. Any questions about a lack of authenticity or presence of tampering will likely render that evidence inadmissible in a court of law. **Admissibility** is the determination that evidence is either acceptable or unacceptable to a court of law. Because the standards for evidence admissibility are so high, forensic investigators must protect all collected evidence through proper handling procedures. The process of collecting evidence, also called evidence **acquisition**, is the starting point where protecting evidence is of the utmost importance.

TIP

In the strictest sense, only evidence that is used in a court of law must be handled with extra precautions. The problem is, though, that often no one knows whether evidence collected will be needed in court or not. Therefore, the best practice for any forensic investigator is to treat all evidence as if it were crucial to a court case. This approach takes more work but ensures that important evidence is not contaminated just because no one thought it would be important. Once evidence gets contaminated, there's no going back.

Whenever a new court case is filed, a common early action is to require a legal hold for data and other items that may be helpful in court. A **legal hold** is a process that requires an organization to preserve and not alter evidence that may be used in court, and it can help ensure that normal data-handling procedures do not contaminate or even delete data that may be needed for a case. Regardless of the existence of a legal hold, a best practice is to always collect and preserve evidence as early as possible. As soon as the investigator collects or seizes evidence, every action and transfer of location or ownership gets meticulously documented. This running documentation of what happened to evidence is called the **chain of custody**. The chain of custody is important to establish that evidence was collected and handled using proper techniques and procedures that are required to satisfy evidence admissibility standards. It is also a trusted method to determine the **provenance**, or point of origin, of a piece of evidence. Tracing a piece of evidence backward through the chain of custody log shows everyone who interacted with the evidence, all the way back to its point of origin (collection).

A chain of custody log documents timelines or sequence of events that describe how a piece of evidence was handled, starting with its collection. The first entry for any piece of evidence in a chain of custody log will be the circumstances surrounding its collection. In addition to any descriptive information (e.g., description, model number, serial number, location collected, and photographs), the date and time the evidence was collected is noted. **Time stamps** are often used that correspond to computer log files to help coordinate a sequence of events and are accurate to at least the second, if not the millisecond. To make correlated activities across multiple time zones easier, many time stamps are recorded using a standard time zone, such as Universal Coordinated Time (UTC), and then each local time stamp would include a **time offset** to translate the coordinated time into a local time. For example, assume a data file gets collected as evidence from a computer in Atlanta, Georgia, on February 19, 2021, at 11:15 a.m. The time stamp, using UTC, would be 19 Feb 2021 16:15 UTC, with a time offset of -5 (because eastern standard time is five hours behind UTC).

Physical tags are commonly affixed to evidence to associate the physical item with the chain of custody log entry. To help validate the integrity of the

entire evidence collection and handling process, forensic investigators commonly create a video recording of each evidence interaction.

All types of evidence are subject to the chain of custody procedures. Anything that attorneys may use in a court of law should be entered as evidence and managed through the chain of custody. Some types of evidence are physical devices, such as disk drives, while others consist of data of various formats. Such data could be generated reports from application software or utilities, event logs that devices and software use to record noteworthy events, or documents that contain the notes taken during interviews. Regardless of the source of the data, a primary concern for collected evidence is the **preservation** of its collected state, which means assurance that evidence remains unchanged from its state when it was collected. The problem with preservation is that most file systems that store data files are designed to allow changes to file contents. One approach to guarantee preservation would be to use only devices and file systems for evidence storage that disallow any changes to data once that data gets initially stored, but such an approach would be expensive and require excessive amounts of storage media.

Another approach is to take a mathematical snapshot of the original data and use that snapshot to determine whether the data changes. A mathematical function that takes arbitrary data as input and returns a fixed-length output (number) is called a **hash function**. Hashing is a shorthand way of saying that you applied a hash function to some data. A useful property of a hash function is that any changes to the original data result in a completely different output, and it is extremely difficult (if nearly impossible) to figure out the original data if you have the hash function output. Forensic investigators routinely collect digital evidence and immediately calculate hash values, which become part of the chain of custody, for each collected file. When the evidence is used, a new hash value is taken and then compared to the original value. If the two hash values are the same, that means the evidence has not changed since it was collected and its integrity is verified. You may also hear the term *checksum* used as a synonym for hash function. While the terms are not technically interchangeable, a checksum is a specific implementation of a general hash function.

Imaging Original Evidence

A cardinal rule of proper evidence handling is to maintain its pristine state, but digital evidence can leave much opportunity for contamination. All an investigator has to do is use the wrong options for a copy command and valuable evidence could get altered or destroyed. Because it is so easy to alter digital data, digital forensic investigators take extreme measures to avoid ever interacting with the original copy of evidence.

The first step in handling digital evidence properly is to create a forensically sound image of any evidence immediately after collection. Two common methods to protect evidence during imaging is to use forensic software that forces read-only mode or connect the evidence device using a hardware interface that blocks any write operations. Once imaging is complete, the original should be locked away in a safe locker for secure storage. Then, the copy can be used for analysis without worrying about contaminating valuable evidence. In fact, many investigators make a secondary copy from the first copy for actual analysis work. That way, if the secondary copy gets contaminated, you do not have to go back to the original. The original can just stay in the secure locker.

Operating System Forensics

The overwhelming majority of computers and devices encountered in an investigation run a general-purpose operating system (OS). The term *device* can be used in many ways, but in this section we will use it to refer to a type of hardware that is intended to carry out a limited range of functions. A device could be a router, a network storage unit, a camera, or a diverter to route packages along a conveyor system in a warehouse. Most complex devices run an OS that is similar to general-purpose computers. Other special-purpose devices, like the diverter, may not have an OS at all but have just its instructions, called firmware, stored in an onboard chip. The term *firmware* indicates that software is stored directly in the hardware, as opposed to on a separate storage unit within a file system.

The three OSs you will likely encounter most often when examining computers and many devices are Windows, Linux, and macOS. (Mobile devices, such as smartphones and tablets, run different OSs that you will learn about in the next section.) Successfully and consistently identifying and gathering evidence from any of these OSs requires an in-depth knowledge of how a specific OS operates. You do not have to be an OS expert, but, if your OS knowledge is lacking, you will struggle and miss important evidence sooner or later. Most people are comfortable with one primary OS and tend to lean toward their comfort zone when selecting investigative hardware and software. While there is nothing wrong with making a choice based on expected productivity due to comfort level, do not shy away from rolling up your sleeves and learning about a different OS if you are called to work with it.

Because the main activities of any digital forensic investigator are to identify, acquire, and analyze digital evidence, it is important to understand how various OSs process and store that evidence. When you get the call to investigate an incident, where do you look for evidence? If you determine that you need an image of main memory, you must have a deep enough understanding of the OS to know where and how it stores data in memory, which is why OS forensics is important. The OS is the keeper, and gateway,

to most of the digital evidence you need for any investigation. If you are not comfortable working with the OS, your investigative tasks are going to be extremely challenging.

As an example of why an investigator needs a thorough understanding of a target OS, consider an investigation that involves malware. During the initial stages of the investigation you find that a previously unknown process stopped running when you scanned the process table. Knowing how the OS works, you look at areas on the disk that may contain copies of currently or previously running processes. Modern OSs do a good job of running many more simultaneous processes than the hardware can support. If the computer has eight CPU cores, you would think that it could run only eight processes simultaneously. However, one important job of the OS is to support many more processes, which it does by allowing a process to execute for only a tiny amount of time and then giving the CPU to another process. It can do this by taking the instructions and memory of a running process and writing to a special file, called a **pagefile**, and then loading another process and running it. A modern OS makes these context switches many times each second, which gives the illusion that hundreds of processes are running at the same time. And, in some cases, processes that are running need more memory than the computer can physically support. In those cases, some pages of memory are written to another file, called a **swapfile**, and then the page of memory can be used to store different data. As a rule of thumb, paging (i.e., writing to and reading from the pagefile) is normal, while swapping (i.e., writing to and reading from the swapfile) is not. If you are swapping a lot, you probably need to add memory. Understanding paging and swapping is just one example of why an investigator needs in-depth OS knowledge.

Internals and Storage

At their core, all OSs do only a few things: set up tables of data and handle memory, processing, and interfaces with external storage and communication. Although that may sound simplistic, there is a lot to just those "things" an OS does. Each OS initiates and maintains data structures in memory while the computer or device is running. The core OS data and functions are often called the *kernel*. The Windows kernel looks different from a Linux or macOS kernel. Likewise, the way in which Windows stores files is different

from Linux or macOS. And, although Linux and macOS have similar roots, each one is slightly different than the other. For example, Windows computers store files mostly using the FAT32 or NTFS file system, the Linux computers commonly use the ext3 or 3xt4 file systems, and macOS uses the Apple File System (APFS).

If you are interested in learning more about OS forensics for the main operating systems, see the Jones & Bartlett Learning *System Forensics, Investigation, and Response* text. The digital forensics book includes a separate chapter for each of the main OSs, with specifics on how to carry out forensic investigations in each one.

Command-Line Interface and Scripting

The most common and convenient way to access memory, files, and functionality in any OS is via the command-line interface. While most end users prefer a GUI that supports a pointing device and graphics, most administrators and investigators prefer the command line. The command-line interface allows users to type specific commands with a wide variety of options to get the specific results desired. Command-line commands can also easily be linked together and even put into a script, which is a text file with multiple commands that can be executed with a simple command. Scripting is a core skill that administrators and investigators must master.

The most common command-line interfaces depend on the OS in use. For Windows, the cmd.exe command prompt and PowerShell command shell are the two most popular command-line interfaces. The cmd.exe command prompt has been a part of Windows from the beginning (although it used to be called command.com in Windows 9x), and PowerShell was released in 2006. PowerShell is a robust administration environment, complete with its own scripting language. Although initially intended for Windows computers, PowerShell was released as an open source product in 2016 for Windows, some Linux variants, and macOS.

In Linux and macOS, the command-line interface environments are implemented as shells, which are user interface environments that provide a prompt for the user to type commands. A variety of shells are available, with most being descendants of the two (almost) original UNIX shells, the Bourne shell from AT&T UNIX and csh from Berkeley UNIX. Today, a variant of the

Bourne shell, bash (the Bourne-again shell), is the default form of many Linux distributions and was also the default form for earlier versions of macOS. However, the default shell for today's macOS is zsh. Each shell provides different scripting, history, and process management capabilities. Most administrators and investigators choose a favorite shell and stick with it. Despite different Linux and macOS versions implementing different default shells, it is not difficult to launch a favorite shell to interact with the OS.

One of the most important skills a digital forensic investigator should develop is that of automating tasks through scripts. Writing scripts helps you learn the OS, how it handles data, and how it manages processes. The ability to quickly write effective and efficient scripts can transform a tedious investigation that cannot keep up with the workload to one that meets deadlines. Scripts can reduce the tedious tasks in every investigation and allow the investigator to focus on higher-level activities and analysis. If you are new to scripting, spend some time learning bash and PowerShell. Those two environments will serve you well when investigating nearly any computer you will encounter.

Mobile Forensics

Computing technology has undergone several dramatic transformations over the past 100 years. At first, computers were room size and existed only at research universities and then were almost room size and could be found at a few large corporations. The 1970s and 1980s saw dramatic changes that resulted in mini-computers and even personal computers that could fit on an average-size desk. The following decades have seen a rapid acceleration in computing device speed and portability, along with faster wired and wireless communication. With the explosion of fast cellular coverage availability, the demand was created for ultra-portable, always connected computing devices. These devices, mainly smartphones and tablets, are what we call *mobile devices*.

Mobile devices are small, powerful, portable, and virtually always connected to the Internet. They have become trusted companions and portals that allow us to stay continuously connected with others and make it easy to store volumes of handy personal information. Mobile devices also host a variety of sensors that can determine location, current weather conditions, and trajectories of travel, which are all properties that make mobile devices extremely valuable to attackers. Compromising a single mobile device can be more profitable than breaking into its owner's home.

Although there have been multiple OSs designed for mobile devices, today's devices almost all run with either iOS or Android. Thus, a forensic investigation that involves mobile devices will likely use one of them. Although mobile devices are computers and the OS each one runs is a true OS, we separate mobile device forensics from computer forensics because of the different nature of the devices. Because mobile devices are designed to be mobile, the range of communication options is generally greater than standard computers support, and the nature of the device's use tends to be more personal.

Mobile Device Evidence

When compared to traditional computing devices, mobile devices generally do not store a large volume of data. While it is not hard to find a smartphone with 512 GB of storage or a tablet with 1 TB, most traditional computers (even lightweight laptops) can support far more storage. Mobile devices tend to use their local storage sparingly and rely on connected (generally cloud-based) data repositories for much of their functionality.

The evidence you will find on a mobile device will most likely be historical details about online access and physical movements. A mobile device's sensors and logs of activity can paint a clear picture of where that device has been and what it was accessing. For instance, many jurisdictions in the United States have enacted restrictions against texting while driving. Therefore, a thorough vehicle accident investigation should include an analysis of the driver's mobile device use leading up to the time of the accident. If it can be shown that the driver was texting at the time of the accident, the driver could be subject to liability and perhaps even punishment.

Investigators have access to a wide variety of digital evidence on mobile devices. While there is no end to the types of interesting evidence you might find on a mobile, here is a brief list of some of the more common types of information that may be of interest:

- Call history
- Email and text messages, including app-specific messages
- Pictures and videos (these can sometimes provide graphic evidence)
- Device information
- Global positioning system (GPS) information and history
- Network connection information and history

Even if a mobile device is deemed not to be a direct part of a crime or incident, its ability to record the environment of an attacker during the incident could be material.

Seizing Evidence from a Mobile Device

The first concern to resolve before searching a mobile device for evidence is no different from searching any other device in that the investigator must have a legal authority to search the device, which is typically easier to acquire for traditional computers, but not always. On-premises servers and networking hardware almost always belong to an organization; if that organization grants access, you have permission. Personally owned computers (such as laptops) and mobile devices may pose some challenges. It is a good idea for organizations to set expectations for personal device use and even grant preemptive search permission for personal devices used for work in an employment agreement. The key is to search computers and devices only after getting the owner's permission or a court order.

Once you have a green light to search a mobile device and seize evidence, you must take extra precautions to uphold proper evidence handling procedures. Mobile devices are designed to be interactive and always connected, and many of them have built-in support for remote tracking and data destruction. If your smartphone is stolen, you can remotely send a signal to wipe all your personal data before an attacker can get to it. While this is a great feature for personal privacy, it could allow criminals to hand over their phones and then send the command to wipe all the evidence.

To prevent a loss of evidence, there are special procedures for mobile devices. Shutting down a device to preserve evidence may make things harder for the investigator. You may prevent further access to evidence stored on the device and part of the reboot process could be to wipe the evidence if a destroy data message gets delivered on startup. A better way to handle volatile mobile devices is to use a Faraday bag, which is a bag or enclosure that is shielded to stop any electromagnetic emanations from passing into or out of the bag. Thus, putting a mobile device into a Faraday bag essentially cuts it off from the outside world without shutting it down. Investigators can use a Faraday bag to avoid any outside communication while searching a mobile device and seizing evidence.

The process of accessing evidence on a mobile device is like that on a normal computer. The investigator attaches a physical connector to the mobile device and uses forensic software to query, search, and seize data from the device. Different manufacturers, and even different models from the same manufacturer, use different power and data connections. A well-

equipped forensic lab will have a variety of power and data connectors that support a variety of mobile devices.

Both FTK and EnCase provide the ability to image and examine mobile devices. In addition to these two forensic products, there are other products that are specifically designed to support mobile device forensics. Here is a list of forensic software for mobile device forensics:

- **Belkasoft Evidence Center**—Supports computers and mobile devices (*https://belkasoft.com/x*)
- **Cellebrite UFED**—The most popular mobile forensic software suite (*https://en.wikipedia.org/wiki/Cellebrite*)
- **Oxygen Forensic Detective**—Advanced forensics for a wide variety of devices (*www.oxygen-forensic.com/en/*)
- **Elcomsoft Mobile Forensic Bundle**—Single-source mobile forensic software (*www.elcomsoft.com/emfb.html/*)
- **Susteen Secure View**—Mobile device evidence acquisition and analysis (*www.secureview.us/*)
- **MOBILedit Forensic Express**—Complete mobile device investigation support (*www.mobiledit.com/*)
- **MSAB XRY**—Focus is on mobile device data extraction (*www.msab.com/products/xry*)

Although both the chain-of-custody and proper evidence-handling techniques are important for all devices, pay careful attention when handling mobile devices because they can be volatile and remotely managed. Carefully isolate the device first, and then use a reputable forensic software suite to access and image the device. One common obstacle is the existence of any user access controls, such as a strong passcode and encrypted data. Many options are available for breaking access controls, but there is no guarantee that you will be able to access the device's data without the owner's cooperation. Fortunately, most mobile device users lack the discipline to maintain strict security practices for a long period of time. Do not count on a lazy mobile device user, but do not ignore the possibility either.

As technology continues to offer smaller devices that are continuously connected, those devices will be of greater interest to investigations of all

types. Mobile device forensics is one of the core competencies every digital forensic investigator should pursue.

CHAPTER SUMMARY

In this chapter, you learned about digital evidence that helps explain what happened during a cyberattack. You got an overview of how to identify, collect, and properly handle digital evidence to support an investigation that may lead to legal action. You learned about basic digital forensics and building a lab to collect and analyze evidence. You learned how recover data that had been deleted or is stored on damaged media. You also learned how to build a team to respond to incidents and prepare to collect critical evidence from computers and devices running different OSs. And finally, you learned about OS and mobile device forensics.

KEY CONCEPTS AND TERMS

Acquisition
Admissibility
Cache
Chain of custody
Data recovery
Digital forensics
E-discovery
Evidence
Forensics
Hash function
Legal hold
Order of volatility
Pagefile
Preservation
Provenance
Swapfile
Time offset
Time stamp

CHAPTER 12 ASSESSMENT

1. Which type of evidence helps explain other evidence?

   A. Demonstrative

   B. Documentary

   C. Real

   D. Testimonial

2. Which type of cybercrime predominantly involves state actors as either targets or perpetrators?

   A. Identity theft

   B. Online fraud

   C. Cyberterrorism

   D. Cyberstalking

3. Which organization is composed of volunteers whose goal is to enhance sharing of knowledge and ideas about digital forensics research?

   A. SWGDE

   B. DC3

   C. DFRWS

   D. CERIAS

4. What is a popular Linux operating system distribution that is a favorite of penetration testers?

   A. EnCase

   B. Kali

   C. FTK

   D. AnaDisk

5. Proper handling is necessary to protect the _____ of evidence.

A. Currency

B. Relevance

C. Accuracy

D. Admissibility

6. What process requires that an organization preserve and not alter evidence that may be used in court?

A. Legal hold

B. Chain of custody

C. Provenance

D. Due diligence

7. A mathematical function that takes arbitrary data as input and returns a fixed-length output, used to ensure integrity of data, is called a _____.

A. Signature

B. Recovery

C. Hash

D. Certificate

8. Which popular mobile forensic software suite is commonly used to extract evidence from a wide variety of mobile devices?

A. Helix

B. Cellebrite UFED

C. Kali

D. DiskDigger

9. Which type of operating system file gets written to and read from frequently as a part of normal operation?

A. Cache

B. Swapfile

C. Pagefile

D. Kernel

10. Which popular command-line interface environment was originally introduced for Microsoft Windows but is now available as an open source product for Windows, Linux, and macOS?

A. cmd.exe

B. bash

C. ksh

D. Powershell

PART III
Information Security Standards, Certifications, and Laws

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CHAPTER 13 Information Security Standards
CHAPTER 14 Information Security Certifi cations
CHAPTER 15 Compliance Laws

CHAPTER 13
Information Security Standards

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INFORMATION TECHNOLOGY (IT) ENVIRONMENTS COMPRISE a variety of hardware and software components that service many purposes and work together to support an organization's operations. Because of the complex range of components required to make today's IT work, it is almost unheard of to purchase all hardware and software from one vendor. Therefore, today's organizations build their IT infrastructure from components from multiple vendors—and expect these products to work together.

How can so many products from different vendors work together? They can communicate and collectively work with one another to meet requirements because of **standards**, which are necessary to create and maintain a competitive market for hardware and software vendors. Standards also guarantee compatibility between products from different countries. In short, they provide guidelines to ensure that products in today's computing environments work together.

Several organizations develop and maintain standards for computing devices. In this chapter, you will learn about the most common standards for computer and networking products and services and specifically about those standards that relate to information systems security.

Chapter 13 Topics

This chapter covers the following topics and concepts:

- What standards organizations apply to information security
- What ISO 17799 is
- What ISO/IEC 27002 is
- What PCI DSS is

Chapter 13 Goals

When you complete this chapter, you will be able to:

- Identify prominent information security standards organizations
- Summarize what ISO 17799 contains
- Explain how ISO/IEC 27002 pertains to information security
- Describe Payment Card Industry Data Security Standard (PCI DSS) requirements

Standards Organizations

The earliest computers were custom built for specific purposes. Designers decided how to connect components and how they communicated based on the specific computer's needs. Computers of the day did a great job of carrying out the tasks assigned to them, but they were not able to easily communicate with computers of components built by another vendor. Soon, however, designers realized that by implementing communications standards, they could enable different vendors' components to work together. This standardization increased customer confidence in computers. Customers felt more comfortable buying products based on standards that allowed their investment to work with products from many other vendors. Some proprietary systems, however, did not support standards.

Adhering to standards is necessary to increase market appeal and, in many cases, to comply with regulations. It is important that you know about the most influential organizations that develop and maintain the standards that govern various aspects of computing and network communications.

National Institute of Standards and Technology

The **National Institute of Standards and Technology (NIST)**, a federal agency within the U.S. Department of Commerce, was founded in 1901 as the National Bureau of Standards (NBS) and was the first federal physical science research laboratory. NIST's mission is to "promote U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology in ways that enhance economic security and improve our quality of life." NIST provides standards for measurement and technology on which nearly all computing devices rely and maintains the atomic clock that keeps the official time for the United States. Although NIST is a nonregulatory agency, many organizations respect and adopt its publications.

NIST executes its primary mission through four cooperative programs:

- **NIST Laboratories**—Laboratories that conduct research to advance U.S. technology infrastructure. The nation's industry uses this

infrastructure to improve the quality of products and services.

- **Baldrige National Quality Program**—A national program that empowers and encourages excellence among U.S. organizations, including manufacturers, service organizations, educational institutions, health care providers, and nonprofit organizations, and strives to increase quality and recognize organizations that achieve quality goals.
- **Hollings Manufacturing Extension Partnership**—A network of centers around the nation that offer technical and business assistance to small and medium-size manufacturers.
- **Technology Innovation Program**—Another national program that offers awards to organizations and universities to support potentially revolutionary technologies that apply to critical needs of national interest.

NIST maintains a list of standards and publications of general interest to the computer-security community, called the Special Publications 800 series, which was established in 1990 to provide a separate identity for information technology security publications. The publications in this series report on research and guideline efforts related to computer security in government, industry, and academic organizations.

Many in the field refer to publications in the 800 series by the name *NIST SP*. For example, many people refer to the document titled "NIST Special Publication 800-66" as NIST SP 800-66. (NIST SP 800-66 contains introductory guidance for complying with HIPAA.)

NOTE

You can find more information about NIST on its webpage at *www.nist.gov*. For more information on NIST special publications, see *https://csrc.nist.gov/publications/sp*.

The NIST Special Publications 800 series contains many standards that provide guidance for information systems security activities. **TABLE 13-1**

lists just a few of the resources you can find in the NIST Special Publications 800 series.

TABLE 13-1 NIST Special Publications 800 series sample documents.

Number	Title
800-53 Rev. 5	*Security and Privacy Controls for Information Systems and Organizations*
800-61 Rev. 2	*Computer Security Incident Handling Guide*
800-73-4	*Interfaces for Personal Identity Verification (3 Parts)* *Part 1: PIV Card Application Namespace, Data Model and Representation* *Part 2: PIV Card Application Card Command Interface* *Part 3: PIV Client Application Programming Interface*
800-83 Rev. 1	*Guide to Malware Incident Prevention and Handling for Desktops and Laptops*
800-88 Rev. 1	*Guidelines for Media Sanitization*
800-94 Rev. 1	DRAFT *Guide to Intrusion Detection and Prevention Systems (IDPS)*
800-107 Rev. 1	*Recommendation for Applications Using Approved Hash Algorithms*
800-121 Rev. 2	*Guide to Bluetooth Security*
800-124 Rev. 1	*Guidelines for Managing the Security of Mobile Devices in the Enterprise*
800-133 Rev. 2	*Recommendation for Cryptographic Key Generation*
800-153	*Guidelines for Securing Wireless Local Area Networks (WLANs)*
800-162	*Guide to Attribute Based Access Control (ABAC) Definition and Considerations*
800-164	*Guidelines on Hardware-Rooted Security in Mobile Devices*
800-171 Rev. 2	*Protecting Controlled Unclassified Information in Nonfederal Systems and Organizations*
800-177 Rev. 1	*Trustworthy Email*
800-207	*Zero Trust Architecture*
800-209	*Security Guidelines for Storage Infrastructure*
800-210	*General Access Control Guidance for Cloud Systems*

Starting in 2015, NIST initiated a subseries of special publications, SP 1800, *NIST Cybersecurity Practice Guides*, which extends SP 800 and targets specific issues related to implementing cybersecurity in the public and private sectors. **TABLE 13-2** lists some of the publications within SP 1800.

TABLE 13-2 Selected NIST Special Publications 1800 series documents.

Number	Title
1800-1	*Securing Electronic Health Records on Mobile Devices*
1800-2	*Identity and Access Management for Electric Utilities*
1800-3	DRAFT *Attribute-Based Access Control*
1800-4	*Mobile Device Security: Cloud and Hybrid Builds*
1800-5	*IT Asset Management*
1800-11	*Data Integrity: Recovering from Ransomware and Other Destructive Events*
1800-15	*Securing Small Business and Home Internet of Things (IoT) Devices: Mitigating Network-Based Attacks Using Manufacturer Usage Description (MUD)*
1880-31	DRAFT *Improving Enterprise Patching for General IT Systems: Utilizing Existing Tools and Performing Processes in Better Ways*
1800-33	DRAFT *5G Cybersecurity*

International Organization for Standardization

The **International Organization for Standardization (ISO)**, formed in 1946 and based in Geneva, Switzerland, is a nongovernmental international organization, comprising a network of 165 national standards institutes, whose goal is to develop and publish international standards. ISO's goal is to develop standards that reach consensus between its governmental entities, representing the public sector, and its private entities, representing the private sector.

Although the organization's short name, ISO, appears to be an acronym, it is not. Because ISO is an international organization, its full name is different depending on the language. ISO members agreed on the short name ISO derived from the Greek word *isos*, which means *equal*. ISO strives for consensus, even in the choice of its name. This focus on consensus is what makes ISO such a successful authority in developing and promoting standards in many areas.

ISO publishes many standards for nearly all industries, for example, the International Standard Book Number (ISBN) for the book publishing industry, and the Open Systems Interconnection (OSI) Reference Model for the information technology industry, which is perhaps the best-known ISO standard and is shown in **FIGURE 13-1**. This internationally accepted framework of standards governs how separate computer systems communicate using networks. The reference model contains seven distinct layers that address seven different issues related to networked communications and defines the standards that enable computers and devices from different vendors to communicate.

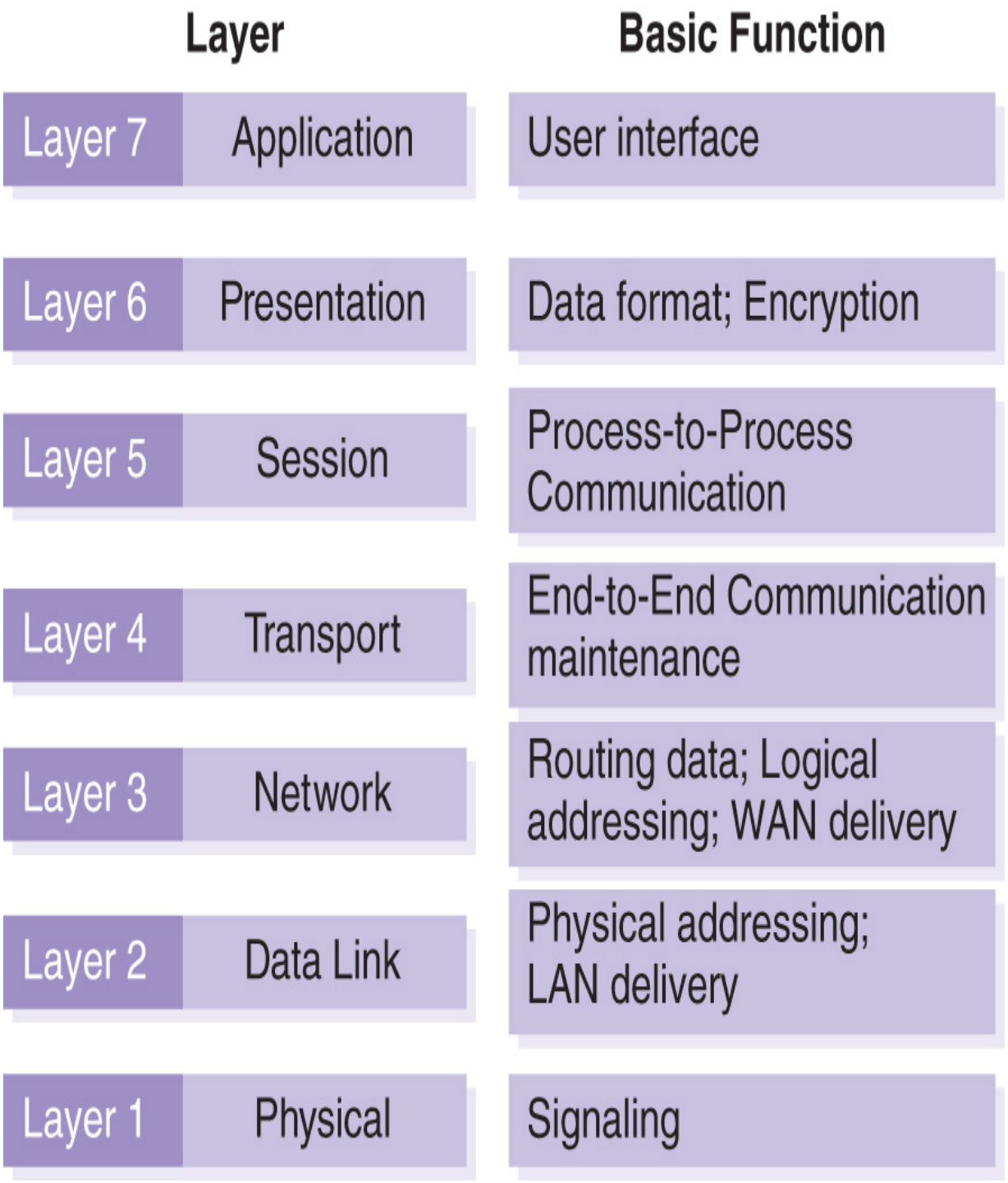

FIGURE 13-1 The OSI Reference Model.

Each layer in the model represents a collection of related functions, and each function provides services to the layer immediately above it and receives services from the layer immediately below it. For example, the

Transport Layer (Layer 4) provides error-free communications across a network as well as the connections needed by software functions in the Session Layer (Layer 5). In addition, it calls functions in the Network Layer (Layer 3), the next layer down, to send and receive packets that comprise the contents of the network communication.

Although many newer networking solutions do not strictly correspond to a structure of seven distinct layers, the OSI Reference Model is still the predominant tool used to teach networking concepts. It has long been the basis of understanding how networks provide general services in a standard environment. Even though other models may map more directly to current software, the OSI Reference Model is still a relevant tool to teach networking fundamentals.

NOTE

You can browse ISO standards and get more information about the organization at its website: *www.iso.org/iso/home.html*.

ISO organizes its many standards by both the International Classification for Standards (ICS) and the Technical Committee (TC), to which it assigns each standard. To give you a feel for the breadth of standards, there are standards spread among 40 different Level 1 ICSs, assigned to one of over 250 TCs.

International Electrotechnical Commission

Often working with the ISO, the **International Electrotechnical Commission (IEC)** is the preeminent organization for developing and publishing international standards for technologies related to electrical and electronic devices and processes. People refer to the collective body of knowledge addressed by the IEC as **electrotechnology**.

The IEC was formed in 1906 to address the issues pertaining to the expanding technologies related to electrical devices. Today, the IEC's

standards address a wide variety of areas, including the following:

- Power generation
- Power transmission and distribution
- Commercial and consumer electrical appliances
- Semiconductors
- Electromagnetics
- Batteries
- Solar energy
- Telecommunications

NOTE

Gauss is a measurement of a magnetic field, *hertz* is a representation of cycles per second, and *weber* is a measure of magnetic flux.

The IEC was instrumental in the development of standards for the electrical measurements gauss, hertz, and weber. The IEC works closely with ISO and the ITU-T (discussed later in the chapter) to synergize efforts. To ensure international acceptance and maximum usage of its standards, the IEC encourages participation from as many countries as possible. At the time of this writing, there are 60 full IEC members, also called National Committees (NCs), and 23 associate IEC members. In 2001 the IEC expanded its membership to include more developing nations, under the Affiliate Country Programme, which includes 84 smaller countries.

As an IT professional, you will most likely encounter IEC standards relating to physical computer and networking hardware. The focus of the IEC has expanded since its inception as the electrical and electronics industries have changed. Today, much of the IEC's focus includes standards that address emerging power needs and how they affect other functional areas. The IEC is active in developing standards that support safety, performance,

environmental responsibility, energy efficiency, and renewable energy sources and use.

NOTE

You can get more information about the IEC organization and its standards at its website: *www.iec.ch*.

World Wide Web Consortium

The creation of the World Wide Web in 1990 marked a turning point in the way users accessed resources on the Internet. In the early days of the Internet, competing vendors released their own versions of the primary language of the web, HyperText Markup Language (HTML), which were incompatible with those of other vendors. These incompatibilities caused issues with web browsers and limited the web's functionality. Thus, as interest in the web grew, the need to standardize its primary language became clear. In answer to the lack of standards, Sir Tim Berners-Lee, the computer scientist who wrote the original proposal for what eventually became the World Wide Web, founded the **World Wide Web Consortium (W3C)** in 1994.

The W3C immediately became the main international standards organization for the World Wide Web, with the stated purpose of developing protocols and guidelines that unify the World Wide Web and ensure its long-term growth. The W3C currently has 419 members, representing businesses, nonprofit organizations, universities, and various government agencies.

The W3C develops many web-related standards that govern and coordinate many aspects of web development and operation. Standards the W3C has developed or endorsed include the following:

- Cascading Style Sheets (CSS)
- Common Gateway Interface (CGI)
- HyperText Markup Language (HTML)
- Simple Object Access Protocol (SOAP)

- Web Services Description Language (WSDL)
- Extensible Markup Language (XML)

Each of these standards and specifications is necessary to ensure that web applications interact with web components from other vendors. If you work with any World Wide Web components, you will likely encounter one or more W3C standards.

NOTE

For more information about the W3C's standards and work in providing standards and guidelines for the World Wide Web, see the W3C website at *www.w3.org*.

Internet Engineering Task Force

According to its website, the purpose of the **Internet Engineering Task Force (IETF)** is to "make the Internet work better," which it does by developing and promoting Internet standards that focus on the engineering aspects of Internet communication and avoid policy and business questions. The IETF works closely with the W3C and ISO/IEC, focusing primarily on standards of the TCP/IP, or Internet Protocol suite. The IETF is an open organization, without membership requirements. All participants, including contributors and leaders, are volunteers, whose work is usually funded by their employers.

NOTE

For more information on the IETF and its activities, visit the IETF webpage at *www.ietf.org*.

The IETF first met in 1986 as a group of 21 researchers who wanted to formalize the main Internet communication protocols and since has evolved to become a collection of working groups (WGs), of which there are currently more than 100, with each group addressing a specific topic. Because WGs tend to operate independently, the IETF sets minimum standards for each group, which has an appointed chair or group of co-chairs and a charter that documents the group's focus and expected deliverables.

Every WG has a dedicated mailing list, which serves as the primary communication medium for its participants and to which anyone can subscribe. In fact, most participants get started by simply subscribing to one or more WG mailing lists of interest. WGs also hold periodic meetings, which are open to all participants, and, although it is generally beneficial to attend meetings, it is possible to participate in a WG by just interacting via the mailing list.

Request for Comments

The IETF produces **requests for comments (RFCs)**, which are documents that range from simple memos to several standards documents, and each RFC's introduction indicates its status. The RFC model allows input from many sources and encourages collaboration and peer review. The IETF publishes guidelines for RFCs. Here are a few points about RFCs:

- **Only some RFCs specify standards**—Only RFCs that open with phrases like "This document specifies . . ." or "This memo documents . . ." should be considered standards or normative documents.
- **RFCs never change**—Any change to an RFC gets a new number and becomes a new RFC. Always look for the latest RFC because previous documents may be out of date.
- **RFCs may originate with other organizations**—The IETF creates only some RFCs. Others may come from independent sources, the Internet Architecture Board (IAB), or the Internet Research Task Force (IRTF).
- **RFCs that define formal standards have four stages**—As an RFC moves from one stage to the next, it becomes more formal, and more organizations accept it. The stages are as follows:

- **Proposed Standard (PS)**—The initial official stage of a standard
- **Draft Standard (DS)**—The second stage of a standard, after participants have demonstrated that the standard has been deployed in working environments
- **Standard (STD)**—The final stage of a standard, after it has been shown to be widely adopted and deployed
- **Best Current Practice (BCP)**—The alternative method used to document operational specifications that are not formal standards

Examples of IETF standards include RFC 5878 and RFC 5910. RFC 5878, "Transport Layer Security (TLS) Authorization Extensions," contains the specification for extensions to the TLS handshake protocol. RFC 5910, "Domain Name System (DNS) Security Extensions [DNSSEC] Mapping for the Extensible Provisioning Protocol (EPP)," describes EPP extension mapping for DNSSEC domain names stored in a central repository. Because these two RFCs contain very technical details that define how the Internet operates, neither of them makes for lightweight reading.

Internet Architecture Board

The IAB is a subcommittee of the IETF and serves as an advisory body to the Internet Society (ISOC). It is composed of independent researchers and professionals who have a technical interest in the well-being of the Internet.

NOTE

You can find more information about RFCs and access an RFC search engine from IETF's RFC webpage at *www.ietf.org/standards/rfcs*.

The IAB serves as an oversight committee for many IETF activities. The IAB provides oversight for the following:

- Architecture for Internet protocols and procedures
- Processes used to create standards

- Editorial and publication procedures for RFCs
- Confirmation of IETF chair and technical area directors

The IAB provides much of the high-level management and validation of the processes of conducting IETF business; it is an important committee that has substantial influence over many standards that affect the Internet.

NOTE

According to the ISOC's website, *www.internetsociety.org*, the ISOC was founded in 1992 as an independent international nonprofit organization, to promote the development of the Internet through leadership in related standards, education, and policy around the world.

Institute of Electrical and Electronics Engineers

According to its website (*www.ieee.org*), the Institute of Electrical and Electronics Engineers (IEEE) is "the world's largest professional association for the advancement of technology." The IEEE is an international nonprofit organization that focuses on developing and distributing standards that relate to electricity and electronics. With more than 419,000 members in over 160 countries, it has the largest number of members of any technical professional organization in the world. The IEEE was formed in 1963 through the merger of two older organizations, the Institute of Radio Engineers, formed in 1912, and the American Institute of Electrical Engineers, formed in 1884.

The IEEE supports 39 societies that focus activities on specific technical areas, which include magnetics, photonics, and computers. Each society develops publications, holds conferences, and promotes activities and events to further knowledge and interest in a specific area. IEEE also provides many training and educational opportunities covering a large number of engineering topics.

IEEE is one of the largest standards-producing organizations, and the standards it produces, which cover many industries including IT, are managed by the IEEE Standards Association (IEEE-SA). IEEE currently publishes or sponsors more than 1,300 standards and projects. The best-known standard that relates to information security is the IEEE 802 LAN/MAN group of standards, which collectively define how various types of local area network (LAN) and metropolitan area network (MAN) protocols work. **TABLE 13-3** lists some of the more recognizable working groups in the IEEE 802 LAN/MAN standard.

TABLE 13-3 Common IEEE 802 standards working groups.

Working Group	Name
802.1	Higher Layer LAN Protocols
802.3	Ethernet
802.11	Wireless LAN (e.g., 802.11a, 802.11b, 802.11g, 802.11n, 802.11ac, and 802.11ax)
802.15	Wireless Personal Area Network (WPAN)
802.16	Broadband Wireless Access (WiMAX)
802.18	Radio Regulatory TAG
802.19	Wireless Coexistence
802.20	Mobile Broadband Wireless Access

NOTE

The 802 working group takes its name from the date it first convened, February (month 2) of 1980.

IEEE is open to members from the technical community who meet certain professional requirements, and only full members can vote in IEEE elections. Students can obtain student memberships to IEEE and can enjoy all the benefits of full membership except the right to vote. For interested parties who are not students and do not meet the technical requirements, IEEE offers associate memberships with limited privileges.

International Telecommunication Union Telecommunication Sector

The **International Telecommunication Union (ITU)**, a UN agency, is responsible for managing and promoting information and technology issues. The ITU is a global point of focus for both governmental and commercial development of networks and related services, with its headquarters in Geneva, Switzerland. It was formed in 1865 as the International Telegraph Union to develop international standards for the emerging telegraph communications industry and became a UN agency in 1947. In 1956 it was renamed the International Telegraph and Telephone Consultative Committee (CCITT), and in 1993, it adopted its current name. Memberships include 193 member states and more than 700 sector members and associates.

The oldest and most recognizable activity of the ITU is its work in developing standards. The **ITU Telecommunication Sector (ITU-T)** performs all ITU standards work and is responsible for ensuring the efficient and effective production of standards covering all fields of telecommunications for all nations. ITU-T also defines tariff and accounting principles for international telecommunication services. Timeliness has become an important focus of ITU-T standards. Thus, in 2001, the organization overhauled its antiquated standards-development procedures to reduce by 95 percent the time required to create standards.

ITU-T calls the international standards it produces **recommendations**, which become mandatory only when adopted as part of a member state's national law. Even though the organization calls its standards recommendations, they tend to carry substantial international authority by virtue of its being a UN agency.

ITU-T divides its recommendations into 26 separate series, each bearing a unique letter of the alphabet. For example, switching and signaling recommendations are in the Q series, and data networks, open systems communications, and security recommendations are in the X series. ITU-T has developed and published many communication recommendations that address technical details of all types of communication. Several of the X series recommendations relate directly to information security. **TABLE 13-4** lists some of the ranges of ITU-T recommendations that relate to information security.

NOTE

You can find more information about ITU and ITU-T on the ITU webpage at *www.itu.int*.

TABLE 13-4 ITU-T recommendations that relate to information security.

ITU-T Recommendation	Description
X.800–X.849: Security	Recommendations in this series address security issues as they relate to different networking layers
X.1000–X.1099: Information and network security	General network security
X.1100–X.1199: Secure applications and services	Ensuring that applications and services are developed and deployed in a secure manner
X.1200–X.1299: Cyberspace security	Overall cybersecurity, identity management, and countering spam
X.1300–X.1399: Secure applications and services	Different from X.1100–X.1199, this series focuses on emergency communications and sensor network security
X.1500–X.1599: Cybersecurity information exchange	Focused on exchanging information between actors in a secure manner
X.1600–X.1699: Cloud computing security	Security topics specifically related to cloud environments
X.1750–X.1799: Data security	Focused on big data security
X.1800–X.1819: 5G Security	Security topics related to 5G communication

American National Standards Institute

One of the leading standards agencies in the United States is the **American National Standards Institute (ANSI)**. Its goal is to strengthen the U.S. marketplace within the global economy and, at the same time, strive to ensure the safety and health of consumers and the protection of the environment. It seeks to accomplish this goal by promoting voluntary consensus standards and conformity assessment systems.

ANSI oversees the creation, publication, and management of many standards and guidelines that directly affect businesses in nearly every sector. Its standards cover such business sectors as acoustical devices, construction equipment, dairy and livestock production, and energy distribution.

ANSI was formed in 1918 through the merger of five engineering societies and three government agencies, all of which merged to form the American Engineering Standards Committee (AESC). In 1928, the AESC became the American Standards Association (ASA), which in 1966 then reorganized and became the United States of America Standards Institute (USASI). Finally, in 1969, the USASI became ANSI. Today, ANSI is composed of government agencies, organizations, educational institutions, and individuals, and it represents more than 270,000 companies and 30 million professionals.

NOTE

You can find more information about ANSI on the organization's webpage at *www.ansi.org*.

ANSI produces standards that affect nearly all aspects of IT. Unlike other organizations that specifically focus on engineering or technical aspects of computing and communication, ANSI primarily addresses standards that support software development and computer system operation. **TABLE 13-5** lists some ANSI standards you will encounter in the information security and software development realms.

TABLE 13-5 Important ANSI standards.

Standard	Description

Standard	Description
ANSI code	The ANSI code is a standard that defines a set of values used to represent characters in computers. A standard is necessary to enable multiple computers to share data and communicate with each other. The ANSI code set is an extension of the older ASCII seven-bit code set.
American Standard Fortran	American Standard Fortran was the first standard programming language, also called Fortran 66. ANSI published this standard language in March 1966.
ANSI C	ANSI published ANSI C as a standard version of the programming language C in 1989.

European Telecommunications Standards Institute Cyber Security Technical Committee

The **European Telecommunications Standards Institute (ETSI)** develops standards, which cover both wired and various wireless communication technologies, for information and communications technologies (ICT) that are commonly adopted by member countries in the European Union (EU), which officially recognizes it as a European Standards Organization. It has more than 800 member organizations from 66 countries. In 2014, ETSI organized a Cyber Security Technical Committee, called TC CYBER, whose purpose is to centralize all cybersecurity standards within ETSI committees. The TC CYBER standards are intended to result in international standards that will initially be adopted by member EU states. These standards focus on security issues related to the Internet and the business communications it transports. The entire organization proposes standards to enforce privacy and security for organizations and citizens across Europe. Although any results published by TC CYBER will be Eurocentric, they will likely have far-reaching effects and impact far beyond European organizations.

ISO 17799 (Withdrawn)

ISO 17799 is an international security standard that was withdrawn not because anything was wrong but because it was so well received and successful that it was completely updated and turned into a new standard with a new name, which you will learn about in the next section. Because ISO 17799's original form was such an important information security standard, it is important to understand it. This standard documents a comprehensive set of controls that represent best practices in information systems. The standard actually consists of two separate parts:

- The ISO 17799 code of practice
- The BS 17799-2 specification for an information security management system

The main purpose of the standard is to identify security controls needed for information systems in business environments. The standard originally appeared as the "DTI Code of Practice" in Britain and was later renamed BS 7799, but it did not gain wide international popularity due to its inflexibility and overly simplistic approach to control. Thus, in 1999 developers released version 2, to address the standard's weaknesses, and submitted it to ISO for accreditation and publishing, and in 2000 ISO published it as ISO 17799.

Several companies began providing tools and services to help implement it, and it quickly became the predominant information security standard. ISO 17799 gave many organizations a framework on which to build their security policy, and full compliance with the standard became a goal. It also became a differentiator among competitors, which enabled potential customers to evaluate organizations on their efforts toward securing data.

The ISO divides the standard into 10 major sections:

- **Security Policy**—A statement of management direction
- **Security Organization**—Governance of information security, or how information security should be enforced

- **Asset Classification and Control**—Procedures to classify and manage information assets
- **Personnel Security**—Guidance for security controls that protect and limit personnel
- **Physical and Environmental Security**—Protection of computer facilities
- **Communications and Operations Management**—Managing technical security controls in systems and networks
- **Access Control**—Controls that limit access rights to network resources, applications, functions, and data
- **System Development and Maintenance**—Guidelines for designing and incorporating security into applications
- **Business Continuity Management**—Protecting, maintaining, and recovering business-critical processes and systems
- **Compliance**—Ensuring conformance with information security policies, standards, laws, and regulations

A newer standard, ISO/IES 27002, has superseded ISO 17799. It provides a generic information security standard accessible by all organizations, regardless of size, industry, or location. Although ISO/IES 27002 replaced the withdrawn ISO 17799, you will still see references to ISO 17799 as a leading information security standard.

ISO/IEC 27002

ISO/IEC 27002, "Information Technology Security Techniques Code of Practice for Information Security Management," appeared in 2005 as an update to the ISO 17799 standard. Originally named ISO 17799:2005, ISO changed its name in 2007 to ISO/IEC 27002:2005, to conform to the naming convention used by other 27000 series ISO/IEC standards. The ISO/IEC 27000 series is a growing family of general information security standards.

Like its predecessor, ISO/IEC 27002 provides organizations with best-practice recommendations on information security management and directs its recommendations to management and security personnel responsible for

information security management systems. Information security is within the standard in the context of the C-I-A triad:

- **Confidentiality**—Ensuring only authorized users, and no one else, can access data
- **Integrity**—Ensuring only authorized users, and no one else, can modify data
- **Availability**—Ensuring that authorized users have access to information when it is requested

ISO/IEC 27002 expands on its predecessor by adding two new sections and reorganizing several others. The ISO divides the new standard into 12 major sections:

- **Risk Assessment**—Formal methods of identifying and classifying risks
- **Security Policy**—A statement of management direction
- **Organization of Information Security**—Governance of information security or how information security should be enforced
- **Asset Management**—Procedures to acquire, classify, and manage information assets
- **Human Resources Security**—Security guidelines for personnel joining, leaving, or moving within an organization
- **Physical and Environmental Security**—Protection of computer facilities
- **Communications and Operations Management**—Managing technical security controls in systems and networks
- **Access Control**—Controls that limit access rights to network resources, applications, functions, and data
- **Information Systems Acquisition Development and Maintenance**—Guidelines for designing and incorporating security into applications
- **Information Security Incident Management**—Anticipating and responding appropriately to information security breaches
- **Business Continuity Management**—Protecting, maintaining, and recovering business-critical processes and systems

- **Compliance**—Ensuring conformance with information security policies, standards, laws, and regulations

The standard specifies and outlines the recommended security controls, which most people regard as best practices, within each section. These best practices provide methods of achieving each objective. ISO/IEC 27002 also provides guidance for implementing each of the recommended controls.

NOTE

You can find more information about ISO/IEC 27002 at the official ISO website, *www.iso.org/standard/50297.html*.

Payment Card Industry Data Security Standard

The Payment Card Industry Data Security Standard (PCI DSS) is an international standard for handling transactions involving payment cards and is developed, published, and maintained by the PCI Security Standards Council (PCI SSC). It is different from other standards you have seen so far in that it was formed by five of the largest payment card vendors in the world, as follows:

- Visa
- MasterCard
- Discover
- American Express
- Japan Credit Bureau (JCB International)

Each of these organizations had its own standard for protecting payment card information before they decided to combine their efforts to publish the first version of the PCI DSS in December 2004. The latest version, PCI DSS version 3.2.1, was released in May 2018. They created PCI DSS to protect payment card users from fraud and to preempt legislative requirements on the

industry. It requires layers of controls to protect all payment card–related information as it is processed, transmitted, and stored. The standard applies to all organizations that participate in any of the processes surrounding payment card processing.

Compliance with PCI DSS standards is a prerequisite for doing business with any of the member organizations. In most cases, noncompliance with PCI DSS standards results in fines and/or more frequent audits, but habitual offenders may find their processing privileges revoked. For most organizations that depend on payment cards as a means of receiving payment, compliance is a business requirement.

The rules with which an organization must comply depend on the number of payment card transactions the organization processes, and all organizations must be assessed at least annually for compliance. Organizations that handle large volumes of transactions must have their compliance assessed by an independent qualified security assessor (QSA), whereas organizations that handle smaller volumes of transactions can choose to self-certify using a PCI DSS self-assessment questionnaire (SAQ).

PCI DSS version 3.2.1 defines 12 requirements for compliance, organized into six groups, called **control objectives**. **TABLE 13-6** lists the 12 PCI DSS control objectives and requirements.

TABLE 13-6 PCI DSS control objectives and requirements.

Control Objective	Requirement
Build and maintain a secure network and systems	Install and maintain a firewall configuration to protect cardholder data Do not use vendor-supplied defaults for system passwords and other security parameters
Protect cardholder data	Protect stored cardholder data Encrypt transmission of cardholder data across open, public networks
Maintain a vulnerability management program	Use and regularly update antivirus software on all systems commonly affected by malware Develop and maintain secure systems and applications
Implement strong access control measures	Restrict access to cardholder data by business need to know Assign a unique ID to each person with computer access Restrict physical access to cardholder data
Regularly monitor and test networks	Track and monitor all access to network resources and cardholder data Regularly test security systems and processes

Control Objective	Requirement
Maintain an information security policy	Maintain a policy that addresses information security

NOTE

You can find more information about PCI DSS at the official PCI Security Standards Council website, *www.pcisecuritystandards.org*.

CHAPTER SUMMARY

A number of organizations define standards that document technical specifications or other specific criteria for use as rules, guidelines, or definitions of characteristics. Organizations and industries also use standards to ensure that products and services are consistent. The ability of different products from different organizations to work well together depends on standards. As the IT industry advances, so does the need for new and updated standards. In this chapter, you learned about some of the standards organizations and a few standards that directly affect information security. Research these standards organizations and familiarize yourself with their work. It is likely you will see them again.

KEY CONCEPTS AND TERMS

American National Standards Institute (ANSI)
Control objective
Electrotechnology
European Telecommunications Standards Institute (ETSI)
International Electrotechnical Commission (IEC)
International Organization for Standardization (ISO)
International Telecommunication Union (ITU)
Internet Engineering Task Force (IETF)
ISO 17799
ISO/IEC 27002
ITU Telecommunication Sector (ITU-T)
National Institute of Standards and Technology (NIST)
Recommendations
Request for comments (RFC)
Standard
World Wide Web Consortium (W3C)

CHAPTER 13 ASSESSMENT

1. The earliest digital computers were the result of experimental standards.
   A. True
   B. False
2. Which standards organization's name derives from the Greek word for *equal*?
   A. IEC
   B. ISO
   C. PCI
   D. W3C
3. Which standards organization formed in 1906 and handles standards for batteries?
   A. IEC
   B. ISO
   C. PCI
   D. W3C
4. Which standards organization publishes standards such as CGI, HTML, and XML?
   A. IEC
   B. ISO
   C. PCI
   D. W3C
5. The IETF primarily focuses on standards of the _____ Internet protocol suite.
6. The IETF produces documents called _____.
7. Which of the following is the most well-known ISO standard?
   A. OSI Reference Model
   B. TCP/IP protocol
   C. TCP/IP Reference Model
   D. OSI protocol

8. The _____ is the world's largest professional association for the advancement of technology.
9. Which standards organization publishes the 802.11ac standard?
   A. ISO
   B. IEC
   C. ITU-T
   D. IEEE
10. Which standards organization publishes American Standard Fortran?
   A. IEEE
   B. ANSI
   C. ITU-T
   D. NIST

CHAPTER 14
Information Security Certifications

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INFORMATION SECURITY IS BECOMING increasingly complex. As software and hardware providers create new and more capable products, attackers find more vulnerabilities. In the process, it becomes more difficult for security professionals to stay current and keep at least one step ahead of the attackers. It is also becoming more difficult for organizations to identify personnel who are qualified to keep their information technology (IT) systems secure.

Today, one of the most popular techniques for identifying the skills a security professional possesses is through **certification**. Certification attests that the holder has obtained a measurable level of competency and may also prove that the holder has a certain level of experience and has passed an examination. Each certification attests to a different skill set and has different requirements.

There are many current certifications that relate to information systems security or cybersecurity personnel in areas ranging from general-level security management to very detailed hands-on practitioners. Regardless of your interest or experience in the information systems security field, there is likely a certification for you. Certifications can help identify you as someone who has pursued training and who complies with the certification's knowledge objectives. In the chapter, you will learn about the most popular information systems security certifications and their requirements.

Chapter 14 Topics

This chapter covers the following topics and concepts:

- What the U.S. Department of Defense (DoD)/military standards for the cybersecurity workforce are

- What the popular vendor-neutral professional certifications are
- What the popular vendor-specific professional certifications are

Chapter 14 Goals

When you complete this chapter, you will be able to:

- Identify professional certifications in the information systems security and cybersecurity space
- Distinguish between the U.S. DoD/military Directive (DoDD) 8570.01 and the new DoDD 8140.01
- Describe popular vendor-neutral professional certifications
- Identify popular vendor-specific professional certifications

U.S. Department of Defense/Military Directive 8570.01

The U.S. DoD has developed many standards and requirements to govern nearly every aspect of daily operation and behavior, including DoDD 8570.01, "Information Assurance Training, Certification and Workforce Management," which defines many requirements for DoD personnel and contractors regarding information security. DoDD 8570.01 requires "all DoD personnel and contractors who conduct information assurance functions in assigned duty positions to achieve very specific levels of certification," all of which differ based on the job. This directive first came out on December 19, 2005, and the latest update incorporated Change 4 on November 20, 2015.

The Gov IT Wiki, *http://govitwiki.com/wiki/8570.01*, is a great resource for additional information on DoDD 8570.01. There, you can find more details about the specific certification requirements for each job type as well as explanations of how the requirement may affect your organization or job. In general, DoDD 8570.01 affects all DoD facility or contractor organizations by ensuring that all personnel who are directly involved with information security possess security certifications. The purpose of this directive is to reduce the possibility that unqualified personnel can gain access to secure information.

NOTE

DoDD 8570.01 has since been replaced by DoDD 8140. Like its predecessor, DoDD 8140 requires DoD IT personnel and contractors to obtain certifications in their work area specializations. DoDD 8140 addresses knowledge, skills, and abilities (KSAs). At the time of this writing, a complementary manual (denoted as 8140.01-M) has been

written but not yet released. Thus, DoDD 8140 has adopted the 8570.01-M until the 8140.01-M is approved.

DoDD 8570.01 has created a new segment of opportunity for training and certification organizations. Therefore, many providers of security training and certifications target DoD employees and contractors to offer paths to DoDD 8570.01 compliance. This mandatory certification requirement has increased the number of personnel who pursue certifications as well as maintaining a steady flow of students through security classes to earn continuing professional education (CPE) credits to keep credentials current. Even though some have questioned its effectiveness, DoDD 8570.01 has increased the number of security personnel seeking ongoing security training.

U.S. DoD/Military Directive 8140

The Defense Information Systems Agency (DISA) is the agency arm of the U.S. DoD that provides IT and communications support to the White House, Secretary of Defense, and all military sectors that contribute to the defense of the United States of America. DISA developed a newer, operationally focused cybersecurity training framework to replace the previous 8570.01 directive, DoDD 8140.

The DoDD 8140 training framework includes training and certification in cybersecurity to prepare DoD personnel to meet the emerging demands of cyberwarfare. The growing demand for effective cyberwarriors cannot be met without a comprehensive standard that sets requirements across multiple schools. A consistent training and certification regimen will result in DoD personnel who are prepared to engage in cyberwarfare, regardless of their department affiliation or background.

The basic tenets for DoDD 8140 for the cybersecurity workforce include the following:

- A “Training Strategy Roadmap” for role-based and crew certification will be provided.
- Commercial certifications, which have long been relied on, although they are often just too broad for military use, will be adapted and

tightened to better meet DoD needs.

- DISA can produce focused, relevant qualifications and certifications for the cyberwarriors of the United States.
- Crew certification is a grouping of qualified role-based operators who obtain the desired effects necessary to defend and operate in cyberspace.
- A "Cyber Defense Academy" will qualify role-based individuals to work effectively as part of crews and teams.
- Joint Cyberspace Training & Certification Standard (JCT&CS) is the current baseline for work-role definition.
- The National Initiative for Cybersecurity Education (NICE) will be the baseline for federal and DoD work-role definitions.

The following DoD initiatives support the DoDD 8140 cybersecurity workforce development standard:

- DoDD 8140 workforce requirements initiative (this defines the requirements for the cybersecurity roles identified by the JCT&CS)
- Learning Management System selection by Office of the Under Secretary of Defense for Personnel and Readiness (OSD P&R)
- JCT&CS concept of operations (CONOPs) and Implementation Plan
- Department of Homeland Security (DHS) and National Security Agency (NSA) Centers of Academic Excellence
- DISA Cyber Workforce Developments

This shift from the previous 8570.01 directive to the more role-based DoDD 8140 provides a more succinct solution to fulfilling the various cybersecurity roles required for combat support. The seven job categories identified by the 8140 directive include the following:

- Securely Provision
- Operate and Maintain
- Protect and Defend
- Analyze
- Collect and Operate

- Oversee and Govern
- Investigate

U.S. DoD Training Framework

Information security is a growing discipline that becomes more complex with every passing day.

To prepare personnel for DoDD 8140, the DoD is creating the 8140 manual as a guide for selecting training. The manual will map skills required for various jobs into one of the seven categories defined by DoDD 8140. The final 8140 manual will likely draw structure and content from the NICE training framework, which aligns specific cybersecurity-related skills with work roles. The NICE framework organizes the KSAs required to carry out tasks into 7 categories, 33 specialty areas, and 52 distinct work roles. DoD contractors and federal agencies can use the NICE framework, and the 8140 manual when released, to determine specific training required for a wide variety of job functions. The shared goal of NICE and DoDD 8140 is to provide guidance that helps ensure all cybersecurity personnel possess the training to best prepare them for their assigned job roles. **TABLE 14-1** shows the NICE framework categories, specialty areas, and work roles.

TABLE 14-1 NICE framework categories, specialty areas, and work roles.

CATEGORY	SPECIALTY AREA	WORK ROLE
Analyze	All-Source Analysis	All-Source Analyst
Analyze	All-Source Analysis	Mission Assessment Specialist
Analyze	Exploitation Analysis	Exploitation Analyst
Analyze	Targets	Target Developer
Analyze	Targets	Target Network Analyst
Analyze	Threat Analysis	Threat/Warning Analyst
Collect and Operate	Collection Operations	All Source-Collection Manager
Collect and Operate	Collection Operations	All Source-Collection Requirements Manager

CATEGORY	SPECIALTY AREA	WORK ROLE
Collect and Operate	Cyber Operational Planning	Cyber Intel Planner
Collect and Operate	Cyber Operational Planning	Cyber Ops Planner
Collect and Operate	Cyber Operational Planning	Partner Integration Planner
Collect and Operate	Cyber Operations	Cyber Operator
Investigate	Cyber Investigation	Cyber Crime Investigator
Investigate	Digital Forensics	Cyber Defense Forensics Analyst
Investigate	Digital Forensics	Law Enforcement/Counterintelligence Forensics Analyst
Operate and Maintain	Customer Service and Technical Support	Technical Support Specialist
Operate and Maintain	Data Administration	Data Analyst
Operate and Maintain	Data Administration	Database Administrator
Operate and Maintain	Knowledge Management	Knowledge Manager
Operate and Maintain	Network Services	Network Operations Specialist
Operate and Maintain	Systems Administration	System Administrator
Operate and Maintain	Systems Analysis	Systems Security Analyst
Oversee and Govern	Cybersecurity Management	Communications Security (COMSEC) Manager
Oversee and Govern	Cybersecurity Management	Information Systems Security Manager
Oversee and Govern	Executive Cyber Leadership	Executive Cyber Leadership
Oversee and Govern	Legal Advice and Advocacy	Cyber Legal Advisor
Oversee and Govern	Legal Advice and Advocacy	Privacy Officer/Privacy Compliance Manager
Oversee and Govern	Program/Project Management Acquisition	IT Investment/Portfolio Manager
Oversee and Govern	Program/Project Management Acquisition	IT Program Auditor
Oversee and Govern	Program/Project Management Acquisition	IT Project Manager

CATEGORY	SPECIALTY AREA	WORK ROLE
Oversee and Govern	Program/Project Management Acquisition	Product Support Manager
Oversee and Govern	Program/Project Management Acquisition	Program Manager
Oversee and Govern	Strategic Planning and Policy	Cyber Policy and Strategy
Oversee and Govern	Strategic Planning and Policy	Cyber Workforce Developer and Manager
Oversee and Govern	Training, Education, and Awareness	Cyber Instructional Curriculum Developer
Oversee and Govern	Training, Education, and Awareness	Cyber Instructor
Protect and Defend	Cyber Defense Analysis	Cyber Defense Analyst
Protect and Defend	Cyber Defense Infrastructure Support	Cyber Defense Infrastructure Support Analyst
Protect and Defend	Incident Response	Cyber Defense Incident Responder
Protect and Defend	Vulnerability Assessment and Management	Vulnerability Assessment Analyst
Securely Provision	Risk Management	Authorizing Official/Designating Representative
Securely Provision	Risk Management	Security Control Assessor
Securely Provision	Software Development	Secure Software Assessor
Securely Provision	Software Development	Software Developer
Securely Provision	Systems Architecture	Enterprise Architect
Securely Provision	Systems Architecture	Security Architect
Securely Provision	Systems Development	Information Systems Security Developer
Securely Provision	Systems Development	Systems Developer
Securely Provision	Systems Requirements Planning	Systems Requirements Planner
Securely Provision	Technology R&D	Research & Development Specialist
Securely Provision	Test and Evaluation	System Testing and Evaluation Specialist

The NICE training framework provides comprehensive descriptions of work roles and specialty areas and guidance for potential and existing information security professionals. People who currently work or want to work in information security can use these standards to ensure they possess the necessary skills. Perhaps more important, these standards lay the groundwork for equipping the next generation of information security professionals in the various job functions.

NOTE

To learn more about the NICE framework, see *https://niccs.cisa.gov/workforce-development/cyber-security-workforce-framework*.

Vendor-Neutral Professional Certifications

A certification is an official statement that validates the fact that a person has satisfied specific job requirements. These requirements often include the following:

- Possessing a certain level of experience
- Completing a course of study
- Passing an examination

An organization that is authorized to assert that an individual has met the certification's requirements issues the certification.

Although certifications are not perfect, obtaining one or more is a common path for security professionals to further their security education and training. Certifications show that a security professional has invested time, effort, and resources into learning more about security. Moreover, many prospective employers consider security certifications as important attributes when they screen job applicants. In reality, true security expertise involves more than merely holding a certification. However, certification preparatory organizations have developed curricula that do an effective job of training certification candidates as well as preparing them for an exam.

Certifications target specific areas of knowledge and expertise. There is at least one certification for most security-related job functions and expertise levels. The first type of certification is the **vendor-neutral certification**. This type of certification covers concepts and topics that are general in nature and does not focus on a specific product or product line. Several organizations provide certifications that the security community recognizes as having high value. The following sections cover some of the many certification organizations and their credentials.

NOTE

A certification does not guarantee that a person is good at a specific job. The reality is that there are bad security professionals who have certifications as well as excellent security professionals who hold no certifications. Typically, if the certification is a professional industry certification, it must undergo a **job task analysis**, a study that identifies the knowledge and skills needed to perform a job. A job task analysis is what makes a professional certification defensible in court given that a thorough and proper job task analysis was conducted.

International Information Systems Security Certification Consortium, Inc.

As one of the most respected global certification organizations, the International Information Systems Security Certification Consortium, Inc. [(ISC)^2] is a not-for-profit organization that focuses on educating and certifying security professionals from all experience levels. (ISC)^2 offers seven main credentials, each addressing a different security professional role. The seven main (ISC)^2 credentials are as follows:

- Systems Security Certified Practitioner (SSCP®)
- Certified Information Systems Security Professional (CISSP®)
- Certified Authorization Professional (CAP®)
- Certified Secure Software Lifecycle Professional (CSSLP®)
- HealthCare Certified Information Security Privacy Practitioner (HCISPP®)
- Certified Cloud Security Professional (CCSP®)
- Associate of (ISC)^2

NOTE

For more information on (ISC)^2 professional certification credentials, visit the (ISC)^2 website at *www.isc2.org*.

SSCP®

The SSCP credential enables security practitioners to demonstrate their level of competence and is ideal for those who are working toward or already hold positions as senior network security engineers, senior security systems analysts, or senior security administrators. The SSCP covers the seven domains of best practices for information security, which are published by $(ISC)^2$ in the SSCP Common Body of Knowledge (CBK).

CISSP®

As the $(ISC)^2$'s flagship credential, the CISSP was the first American National Standards Institute/International Organization for Standardization (ANSI/ISO)-accredited credential in the field of information security. The CISSP provides information security professionals with an objective measure of competence and a globally recognized standard of achievement. The CISSP credential demonstrates competence in the eight domains of the $(ISC)^2$ CISSP CBK and targets middle- and senior-level managers who are working toward or already hold positions as chief information security officers (CISOs), chief security officers (CSOs), or senior security engineers.

NOTE

The CISSP® CBK was changed from 10 to 8 domains. The eight domains of the CISSP CBK are as follows:

- Security and Risk Management
- Asset Security
- Security Architecture and Engineering
- Communications and Network Security
- Identity and Access Management (IAM)
- Security Assessment and Testing
- Security Operations

- Software Development Security

CAP®

The Certified Authorization Professional (CAP) credential provides a method to measure the knowledge and skills necessary for professionals involved in the process of authorizing and maintaining information systems. The best fits for the CAP credential are personnel responsible for developing and implementing processes used to assess risk and for establishing security requirements. Professionals seeking the CAP credential could include authorization officials, system owners, information owners, information security officers, and certifiers. This credential is appropriate for both private sector and U.S. government personnel.

CSSLP®

The CSSLP is one of the few credentials that evaluates professionals for the knowledge and skills necessary to develop and deploy secure software applications. This credential is appropriate for software developers, software architects, and anyone involved in the software development and deployment process.

HCISPP®

The HCISPP was developed to address the health care industry and the protection of protected health care information (PHI) or electronic protected health care information (ePHI). The HCISPP credential tests and evaluates professionals for the knowledge and skills necessary to perform and conduct security and privacy work for health care organizations and is appropriate for individuals seeking an IT or IT security career path within a health care organization.

CCSP®

With the rapid growth in cloud and virtual computing, the CCSP certification was built by both $(ISC)^2$ and the Cloud Security Alliance (CSA). The CCSP credential tests and evaluates professionals for the knowledge and skills

necessary to secure and manage cloud computing environments; it is appropriate for IT, IT security, system administrators, and system architects who are designing, implementing, hosting, and managing applications in cloud infrastructures.

Associate of (ISC)²

The Associate of (ISC)² credential is for aspiring cybersecurity professionals who have not yet met the experience requirements for other (ISC)² certifications. All a candidate must do is pass any one of the (ISC)² certification exams to become an Associate of (ISC)². Once people holding this credential attain the experience required for the exam they passed, the credential can be converted, or upgraded, to the full certification. The Associate of (ISC)² certification gives ambitious cybersecurity personnel a way to show they have the knowledge required for a specific certification even before they have the experience.

(ISC)² Professional Certification Concentrations

After the original conception of the CISSP and the continuous evolution of information systems security, (ISC)² discovered a need to develop concentration credentials that address more advanced content, including information systems security architecture, engineering, and management. These CISSP concentrations are in the following functional areas:

- Architecture (CISSP-ISSAP®)
- Engineering (CISSP-ISSEP®)
- Management (CISSP-ISSMP®)

NOTE

For more information on the CISSP® concentration certifications, visit *www.isc2.org/Certifications/CISSP-Concentrations*.

ISSAP ®.

The ISSAP concentration requires a candidate to demonstrate two years of professional experience in the area of architecture and is an appropriate credential for chief security architects and analysts, who typically work as independent consultants or in similar capacities.

ISSEP ®.

The ISSEP concentration was developed in conjunction with the National Security Administration (NSA) to provide an invaluable tool for systems security engineering professionals. The ISSEP concentration is the road map for incorporating security into projects, applications, business processes, and all information systems.

ISSMP ®.

The ISSMP concentration requires that a candidate demonstrate two years of professional experience in the area of enterprise-wide security operations and management. This concentration contains deeper managerial elements than the CISSP certification, such as project management, risk management, setting up and delivering a security awareness program, and managing a business continuity planning program.

Global Information Assurance Certification/SANS Institute

Another major global ANSI-**accredited** certification organization is the Global Information Assurance Certification (GIAC), which offers approximately 30 individual credentials. These credentials span several information security job disciplines:

- Audit
- Forensics
- Legal
- Management
- Security administration
- Software security

GIAC was formed in 1999 by the SANS Institute, which provides the specific training that prepares students for each of the GIAC-issued credentials. Security professionals can pursue individual GIAC credentials or follow a path to earn higher-level credentials.

Moreover, security professionals can stand out from other GIAC credential holders by adding the Gold credential, which they can do by submitting a technical paper that covers an important area of information security and having it accepted. Another method for security professionals to stand apart from other credential holders is to obtain the GIAC Security Expert (GSE) credential, which is the highest-level credential within GIAC. The GSE requirements include holding three GIAC credentials (with two of the credentials being Gold, denoting an assessed writing component), passing a GSE exam, and completing an intensive two-day hands-on lab.

NOTE

For more information on GIAC security certifications, visit the GIAC website at *www.giac.org/certifications /focus-areas*.

TABLE 14-2 lists the current GIAC credentials organized by focus areas.

TABLE 14-2 GIAC credentials.

FOCUS AREA	CATEGORY	CREDENTIAL
Cyber Defense	Blue Team	GIAC Open Source Intelligence (GOSI)
Cyber Defense	Blue Team	GIAC Certified Intrusion Analyst (GCIA)
Cyber Defense	Blue Team	GIAC Certified Windows Security Administrator (GCWN)
Cyber Defense	Blue Team	GIAC Continuous Monitoring (GMON)
Cyber Defense	Blue Team	GIAC Defensible Security Architecture (GDSA)
Cyber Defense	Blue Team	GIAC Certified Detection Analyst (GCDA)
Cyber Defense	Blue Team	GIAC Certified UNIX Security Administrator (GCUX)

FOCUS AREA	CATEGORY	CREDENTIAL
Cyber Defense	Cyber Defense Essentials	GIAC Information Security Fundamentals (GISF)
Cyber Defense	Cyber Defense Essentials	GIAC Security Essentials Certification (GSEC)
Cyber Defense	Cyber Defense Essentials	GIAC Certified Enterprise Defender (GCED)
Cyber Defense	Cyber Defense Essentials	GIAC Certified Incident Handler (GCIH)
Cyber Defense	Cyber Defense Essentials	GIAC Information Security Professional (GISP)
Cyber Defense	Purple Team	GIAC Defending Advanced Threats (GDAT)
Offensive Operations	Red Team	GIAC Certified Incident Handler (GCIH)
Offensive Operations	Red Team	GIAC Python Coder (GPYC)
Offensive Operations	Red Team	GIAC Enterprise Vulnerability Assessor (GEVA)
Offensive Operations	Penetration Testing	GIAC Certified Penetration Tester (GPEN)
Offensive Operations	Penetration Testing	GIAC Web Application Penetration Tester (GWAPT)
Offensive Operations	Penetration Testing	GIAC Mobile Device Security Analyst (GMOB)
Offensive Operations	Penetration Testing	GIAC Exploit Researcher and Advanced Penetration Tester (GXPN)
Offensive Operations	Penetration Testing	GIAC Assessing Wireless Networks (GAWN)
Offensive Operations	Penetration Testing	GIAC Cloud Penetration Tester (GCPN)
Offensive Operations	Purple Team	GIAC Defending Advanced Threats (GDAT)
Digital Forensics & Incident Response	Operating System & Device In-Depth	GIAC Battlefield Forensics & Acquisition (GBFA)
Digital Forensics & Incident Response	Operating System & Device In-Depth	GIAC Certified Forensic Examiner (GCFE)
Digital Forensics & Incident Response	Operating System & Device In-Depth	GIAC Advanced Smartphone Forensic (GASF)
Digital Forensics & Incident Response	Incident Response & Threat Hunting	GIAC Certified Forensic Analyst (GCFA)
Digital Forensics & Incident Response	Incident Response & Threat Hunting	GIAC Network Forensic Analyst (GNFA)
Digital Forensics & Incident Response	Incident Response & Threat Hunting	GIAC Cyber Threat Intelligence (GCTI)
Digital Forensics & Incident Response	Incident Response & Threat Hunting	GIAC Reverse Engineering Malware (GREM)
Digital Forensics & Incident Response	Incident Response & Threat Hunting	GIAC Certified Incident Handler (GCIH)
Digital Forensics & Incident Response	Incident Response & Threat Hunting	GIAC Response and Industrial Defense (GRID)
Cloud Security	Cloud Security Techniques	GIAC Cloud Security Essentials (GCLD)
Cloud Security	Cloud Security Techniques	GIAC Certified Web Application Defender (GWEB)
Cloud Security	Cloud Security Techniques	GIAC Cloud Security Automation (GCSA)
Cloud Security	Cloud Penetration Testing	GIAC Cloud Penetration Tester (GCPN)

FOCUS AREA	CATEGORY	CREDENTIAL
Management, Legal, and Audit	Management	GIAC Security Leadership Certification (GSLC)
Management, Legal, and Audit	Management	GIAC Strategic Planning, Policy, and Leadership (GSTRT)
Management, Legal, and Audit	Management	GIAC Certified Project Manager Certification (GCPM)
Management, Legal, and Audit	Legal	GIAC Legal Issues (GLEG)
Management, Legal, and Audit	Audit	GIAC Systems and Network Auditor (GSNA)
Management, Legal, and Audit	Audit	GIAC Critical Controls Certification (GCCC)
Industrial Control Systems	Audit	GIAC Global Industrial Cyber Security Professional (GICSP)
Industrial Control Systems	Audit	GIAC Response and Industrial Defense (GRID)
Industrial Control Systems	Audit	GIAC Critical Infrastructure Protection (GCIP)

Certified Internet Web Professional

Certified Internet Web Professional (CIW) offers several credentials that focus on both general and web-related security. Several of CIW's advanced credentials require a combination of passing an exam and holding at least one recognized credential from another vendor, an approach that encourages a breadth of security knowledge and skills. **TABLE 14-3** lists the CIW security-related credentials and their general requirements.

TABLE 14-3 CIW credentials.

CREDENTIAL	REQUIREMENTS
CIW Web Security Associate	Pass Web Security Associate exam (1D0-571)
CIW Web Security Specialist	Pass Web Security Associate exam (1D0-571), plus earn one credential from the CIW-approved credential list
CIW Web Security Professional	Pass Web Security Associate exam (1D0-571), plus earn two credentials from the CIW-approved credential list

The CIW-approved credential list contains the credentials from other vendors that satisfy the CIW Web Security Specialist and CIW Web Security

Professional credentials. Other credentials that satisfy CIW requirements include the following:

- $(ISC)^2$ SCCP or CISSP
- Various GIAC credentials, such as GSE and GCIH
- CompTIA Security+
- Several vendor-specific credentials

NOTE

For more information about CIW credentials and current requirements, see the CIW website at *www.ciwcertified.com*.

CompTIA

CompTIA's Security+ certification is a globally recognized, vendor-neutral, entry-level certification for any IT or IT security professional who wants to pursue further work and knowledge in this area. The certification is postured to reach the masses of recent college graduates or entry-level IT professionals who are trying to decide what specific career path to take within IT, security being one of them.

For those professionals seeking an entry-level information systems security or cybersecurity certification credential, the CompTIA Security+ certification has the following benefits:

- Is a globally recognized credential with certified professionals in more than 100 countries
- Meets the ISO 17024 standard and is approved by the DoD 8570.01-M requirements
- Is industry supported given that it is developed and maintained by leading IT experts
- Provides a career path in information systems security and the pursuit of additional security certifications

For security professionals possessing 5 to 10 years of experience, CompTIA offers the CompTIA Advanced Security Practitioner (CASP™) credential. According to CompTIA's website, CASP "meets the ISO 17024 standard and is approved by U.S. Department of Defense to fulfill directive 8140/8570.01-M requirements."

NOTE

For more information on CompTIA's credentials, visit its website at *www.comptia.org/certifications*.

ISACA®

ISACA, formerly known as the Information Systems Audit and Control Association, is a nonprofit global organization that promotes "the development, adoption, and use of globally accepted, industry-leading knowledge and practices for information systems." ISACA provides security training at conferences and training events. The organization offers four certification programs for IT security professionals. **TABLE 14-4** lists the ISACA certifications.

TABLE 14-4 ISACA certifications.

CERTIFICATION	DESCRIPTION
Certified Information Security Manager (CISM)	The CISM certification program is a credential for experienced information security professionals who are involved in security management. It provides a way to measure the knowledge and skills necessary to design, implement, and manage enterprise security programs.
Certified Information Systems Auditor (CISA)	The CISA certification program targets information systems audit, control, and security professionals. It defines and promotes the skills and practices that are the building blocks of success in the IT audit and control field.

CERTIFICATION	DESCRIPTION
Certified in the Governance of Enterprise IT (CGEIT)	The CGEIT is a new ISACA certification program. It targets security professionals who ensure that their organization satisfies IT governance requirements. The CGEIT bases its requirements on the ISACA and the IT Governance Institute's (ITGI's) audit and control guidelines, which come from global subject matter experts.
Certified in Risk and Information Systems Control (CRISC)	The CRISC certification applies to a wide range of security professionals. It focuses on the knowledge and skills required to design, deploy, monitor, and manage security controls to address risk. CRISC addresses all risk management areas, including identification, assessment, response, and monitoring.
Certified Data Privacy Solutions Engineer (CDPSE)	The CDPSE certification targets IT professionals specializing in how privacy laws and regulations affect the organization's whole environment: systems, network, and applications.
Cybersecurity Practitioner Certification (CSX-P)	The CSX-P certification applies the five security functions of the National Institute of Standards and Technology (NIST) Cybersecurity Framework—Identify, Protect, Detect, Respond, and Recover—to certify a baseline understanding for security professionals.
Information Technology Certified Associate (ITCA)	The ITCA certification validates a foundational understanding of IT. The certification targets individuals who desire a career in IT but lack real-world IT experience.

NOTE

You can learn more about ISACA's certifications and its requirements at the ISACA website at *www.isaca.org*.

Other Information Systems Security Certifications

There are many other valuable vendors and certifications that address niche areas in the discipline than the ones previously discussed. The following table of certifications is not an exhaustive list; rather, it is a starting point for researching some of the many available options. Before deciding on the right certification to pursue, research the most current offerings in your area of

interest because vendors continually introduce new certifications and frequently update their existing products. Make sure that you conduct your own search for the latest information on the certifications you most want to pursue. **TABLE 14-5** lists some of the more popular certifications that have not been covered thus far in the chapter.

TABLE 14-5 Additional information systems security certifications.

VENDOR	CERTIFICATIONS	FOR MORE INFORMATION
International Council of E-Commerce Consultants (EC-Council)	Certified Ethical Hacker (CEH) Computer Hacking Forensic Investigator (CHFI) EC-Council Certified Security Analyst (ECSA)/Licensed Penetration Tester (LPT)	*http://cert.eccouncil.org/*
Software Engineering Institute—Carnegie Mellon University	CERT—Certified Computer Security Incident Handler SEI—Authorized CERT Instructor	*www.sei.cmu.edu/education-outreach/credentials/*
Mile2	Multiple security certifications	*www.mile2.com/*
Certified Wireless Security Professional	Multiple wireless security certifications	*www.cwnp.com/it-certifications/*
High Tech Crime Network	Certified Computer Crime Investigator (Basic, Advanced) Certified Computer Forensic Technician (Basic, Advanced)	*www.htcn.org/site/certification-requirements.html*
The International Society of Forensic Computer Examiners	Certified Computer Examiner (CCE)	*www.isfce.com/certification.htm*
CyberSecurity Institute	CyberSecurity Forensic Analyst (CSFA)	*www.cybersecurityforensicanalyst.com/*
Offensive Security	Multiple certifications	*www.offensive-security.com/information-security-certifications/*

Vendor-Specific Professional Certifications

Several vendors of hardware and software products also offer certification programs. These **vendor-specific certifications** help identify professionals who possess in-depth product knowledge. Many organizations use these certifications, along with vendor-neutral certifications, when evaluating prospective employees and personnel. As with vendor-neutral certifications, holding a certification for a specific vendor does not guarantee competence, but it does imply it. If an applicant meets the requirements for a certification, it means that applicant has a certain level of knowledge and skills.

In this section, you will learn about some of the vendor-specific certification programs, but, because many vendors offer certifications other than those discussed and certification programs change frequently, you should visit the vendor website for each of the software and hardware products active in your IT infrastructure. The following sections introduce a few of the many vendor-specific certifications for security personnel.

Cisco Systems

Cisco Systems, one of the largest manufacturers of network security devices and software, offers a range of certifications for its networking products. Its training and certification process help ensure that security professionals who work with Cisco products possess the knowledge and skills they need to secure their environments. To do this, Cisco offers five certification levels along different tracks to address the needs of professionals with different experience levels. These options enable security professionals to focus their efforts on the specific knowledge and skills they need to get the most out of their Cisco equipment.

Entry-level professionals can work their way up the sequence with additional training and experience. Those who already possess substantial Cisco equipment experience may choose to start with a higher level. Cisco offers certifications at these levels:

- Entry

- Associate
- Specialist
- Professional
- Expert

NOTE

For more information on Cisco's certification programs, visit the Cisco website at *www.cisco.com/c/en/us/training-events/training-certifications/certifications.html*.

Cisco challenges applicants differently, depending on the level of certification. Entry-level certifications require only a single exam, whereas more advanced certifications require multiple courses and exams. Cisco also offers multiple paths for associates, professionals, and experts. These paths enable Cisco credential holders to specialize in specific areas. You can earn a Cisco certification from the following technology groups:

- Collaboration
- CyberOps
- Data Center
- DevNet
- Enterprise
- Security
- Service Provider

TABLE 14-6 lists the Cisco certifications.

TABLE 14-6 Cisco certifi cations.

LEVEL	CERTIFICATION

LEVEL	CERTIFICATION
Entry	Cisco Certified Technician (CCT)
Associate	Cisco Certified Network Associate (CCNA)
	CyberOps Associate
	DevNet Associate
Professional	Cisco Certified Network Professional (CCNP) Collaboration
	Cisco Certified Network Professional (CCNP) Data Center
	Cisco Certified Network Professional (CCNP) Enterprise
	Cisco Certified Network Professional (CCNP) Security
	Cisco Certified Network Professional (CCNP) Service Provider
	CyberOps Professional
	DevNet Professional
Expert	Cisco Certified Design Expert (CCDE)
	Cisco Certified Internetwork Expert (CCIE) Collaboration
	Cisco Certified Internetwork Expert (CCIE) Data Center
	Cisco Certified Internetwork Expert (CCIE) Enterprise Infrastructure
	Cisco Certified Internetwork Expert (CCIE) Enterprise Wireless
	Cisco Certified Internetwork Expert (CCIE) Security
	Cisco Certified Internetwork Expert (CCIE) Service Provider

Juniper Networks

Juniper Networks manufactures a variety of network security hardware and software as well as offering a varied range of certifications for its networking product line. Like Cisco, Juniper Networks offers multiple certification levels and different tracks to help personnel who work for organizations that use Juniper Networks hardware to get the most from its products.

Certification candidates can take courses and exams to qualify for certifications at four levels from eight tracks, but certifications for all four levels are not offered for every track. **TABLE 14-7** shows the Juniper Networks certification levels and the tracks available at each level.

TABLE 14-7 Juniper Networks certification levels and tracks.

TRACK	JUNIPER NETWORKS CERTIFIED INTERNET ASSOCIATE (JNCIA)	JUNIPER NETWORKS CERTIFIED INTERNET SPECIALIST (JNCIS)	JUNIPER NETWORKS CERTIFIED INTERNET PROFESSIONAL (JNCIP)	JUNIPER NETWORKS CERTIFIED INTERNET EXPERT (JNCIE)
Automation and DevOps	JNCIA-DevOps	JNCIS-DevOps		
Cloud	JNCIA-Cloud	JNCIS-Cloud	JNCIP-Cloud	JNCIE-Cloud
Data Center	JNCIA-Junos	JNCIS-ENT	JNCIP-DC	JNCIE-DC
Design	JNCDA	JNCDS-DC JNCDS-SEC JNCDS-SP		
Enterprise Routing and Switching	JNCIA-Junos	JNCIS-ENT	JNCIP-ENT	JNCIE-ENT
Mist AI	JNCIA-MistAI	JNCIS-MistAI		
Security	JNCIA-SEC	JNCIS-SEC	JNCIP-SEC	JNCIE-SEC
Service Provider Routing and Switching	JNCIA-Junos	JNCIS-SP	JNCIP-SP	JNCIE-SP

NOTE

For more information on Juniper Networks certifications, visit the Juniper Networks website at *www.juniper.net/us/en/training/certification/*.

RSA

RSA is a global provider of security, risk, and compliance solutions for enterprise environments with products that include identity assurance, data loss prevention, encryption, and tokenization devices. It also provides specific training and certifications to help security professionals acquire and demonstrate the knowledge and skills necessary to effectively use RSA products. Because organizations commonly use RSA products in various capacities in an enterprise environment, RSA offers several certification options, of which the current ones are RSA Archer, RSA SecurID, NetWitness, and Identity Governance & Lifecycle. Each certification requires the applicant to take one or more required courses and then pass a required exam.

NOTE

For more information on RSA certifications, visit its website at *https://community.rsa.com/t5/rsa-certification-program/tkb-p/rsa-certification-program*.

Symantec

In 2019, the Broadcom Corporation expanded its wide range of security software products by acquiring the enterprise business security division of Symantec. Like other vendors we've mentioned, Broadcom offers certifications for its product lines. These certifications provide specific product training and validate practitioners' knowledge and skills related to the Symantec product line.

NOTE

For more information about Symantec certifications, visit the Broadcom-website at *www.broadcom.com/support/education/symantec/certification*.

Following is a list of the available certifications in the Symantec Certified Specialist (SCS) program:

- Exam 250-215: Administration of Symantec Messaging Gateway 10.6
- Exam 250-420: Administration of Symantec VIP
- Exam 250-426: Administration of Symantec Data Center Security—Server Advanced 6.7
- Exam 250-428: Administration of Symantec Endpoint Protection 14
- Exam 250-444: Administration of Symantec Secure Sockets Layer Visibility 5.0
- Exam 250-445: Administration of Symantec Email Security.cloud—v1
- Exam 251/250-443: Administration of Symantec CloudSOC—R2
- Exam 251/250-447: Administration of Symantec Client Management Suite 8.5
- Exam 251/250-449: Administration of Symantec Cloud Workload Protection—R1
- Exam 250-556: Administration of Symantec ProxySG 6.7
- Exam 251/250-550: Administration of Symantec Endpoint Security—R1
- Exam 251/250-552: Administration of Symantec Security Analytics 8.0
- Exam 250-554: Administration of Symantec Web Security Service—R1.1
- Exam 251/250-553: Administration of Symantec Data Loss Prevention 15.5
- Exam 251/250-555: Administration of Symantec Endpoint Detection and Response 4.2

Check Point

Check Point is another global manufacturer of network and security devices and software that provides training and certification paths for security professionals to encourage the highest level of knowledge and skills in the

use of Check Point products. Security professionals can follow a prescribed path using Check Point's certification model, which was redesigned for 2021 and now offers two Core certifications, two Security Master certifications, and numerous Infinity Specialist accreditations. All Check Point certifications require that applicants pass an exam that involves 80 percent study materials and 20 percent hands-on experience. Both certifications and accreditations are required for the Check Point path toward advanced certification for applicants who want to achieve higher levels. **TABLE 14-8** shows the Check Point certifications and accreditations for each level.

TABLE 14-8 Check Point certifications.

LEVEL	NAME	PREREQUISITES
Core	Check Point Certified Security Administrator (CCSA)	
Core	Check Point Certified Security Expert (CCSE)	CCSA (recommended)
Security Master	Check Point Certified Security Master (CCSM)	CCSA, CCSE, plus two Infinity Specialist Accreditations
Security Master	Check Point Certified Security Master Elite (CCSM Elite)	CCSE, CCSM, plus two additional Infinity Specialist Accreditations
Infinity Specialist Accreditation	Check Point Certified Automation Specialist (CCAS)	
Infinity Specialist Accreditation	Check Point Certified Maestro Expert (CCME)	
Infinity Specialist Accreditation	Check Point Certified Cloud Specialist (CCCS)	
Infinity Specialist Accreditation	Check Point Certified Endpoint Specialist (CCES)	
Infinity Specialist Accreditation	Check Point Certified Multi-Domain Security Management Specialist (CCMS)	
Infinity Specialist Accreditation	Check Point Certified Virtual System Extension Specialist (CCVS)	
Infinity Specialist Accreditation	Check Point Certified Troubleshooting Administrator (CCTA)	
Infinity Specialist Accreditation	Check Point Certified Troubleshooting Expert (CCTE)	
HackingPoint	AppSec for Developers (CCPE-A)	
HackingPoint	Cloud Security (CCPE-C)	

LEVEL	NAME	PREREQUISITES
HackingPoint	Infrastructure Hacking Checkpoint Certified PenTesting Expert (CCPE-I)	
HackingPoint	Web Hacking Checkpoint Certified PenTesting Expert (CCPE-W)	

NOTE

For more information on Check Point certifications, visit their website at *https://training-certifications.checkpoint.com/#/*.

CHAPTER SUMMARY

In this chapter, you learned about some of the available security certifications. Although security certifications do not guarantee competence, they can provide employers with confidence that the credential holder possesses a standard level of knowledge and skills. Most organizations issue credentials for limited time periods, so you can also determine that a current credential relates to current knowledge and skills. You learned about vendor-neutral and vendor-specific certifications. Organizations such as $(ISC)^2$ and CompTIA offer vendor-neutral professional certifications, whereas vendors such as Cisco, Juniper, and Check Point offer vendor-specific certifications. You also learned about the U.S. DoDD 8570.01, which defines a standard for information assurance training, certification, and workforce management. This directive has been replaced with the newer role-based DoDD 8140 for cybersecurity workforce development.

You should use certifications to help you direct your learning and measure your knowledge and experience throughout your information systems security or information assurance career. However, do not measure your value or abilities only by the number of certifications you hold because, even though employers do use certifications to help assess prospects, the better assessment is the prospect's actual performance.

KEY CONCEPTS AND TERMS

Accredited
Certification
Job task analysis
Vendor-neutral certification
Vendor-specific certification

CHAPTER 14 ASSESSMENT

1. A certification is an official statement validating that a person has satisfied specific requirements.

   A. True

   B. False

2. Which $(ISC)^2$ certification covers seven domains of best practices for information security for practitioners?

   A. CISM

   B. CCNA

   C. SSCP

   D. GSEC

   E. None of the above

3. Which $(ISC)^2$ certification specifically addresses developing secure software?

   A. CISSP

   B. CSSLP

   C. GSEC

   D. CISA

   E. None of the above

4. Which certification is the highest level GIAC credential?

   A. CAP

   B. GSEC

   C. GCIH

   D. GSE

   E. None of the above

5. The _____ Specialist and Professional certifications require that you hold one or more certifications from an approved vendor.
6. Which CompTIA certification targets foundational security topics?

   A. Security+

   B. TIA practitioner

   C. TIA+

   D. Information security practitioner

   E. None of the above

7. Which ISACA certification applies to security auditors?

   A. CISSP

   B. SSCP

   C. GSEC

   D. CCNA

   E. None of the above

8. The _____ professional certification is specific to performing an information systems audit.

   A. CISSP

   B. CISA

   C. GSEC

   D. CCNA

   E. None of the above

9. Which network device manufacturer offers certifications in six levels: entry, associate, specialist, professional, expert, and architect?

   A. Cisco Systems

   B. Check Point

   C. Juniper Networks

   D. Symantec

   E. None of the above

10. Which of the following vendors offers a certification for Data Loss Prevention?

    A. Cisco

    B. Check Point

    C. Juniper Networks

    D. Symantec

    E. None of the above

11. What is the main purpose of DoDD 8140?

    A. It requires that the DoD workforce, including contractors, have a minimum level of training and certifications to perform their job duties.

    B. It requires DoD employees to acquire security training.

    C. It requires DoD employees to acquire security certifications.

    D. It requires DoD facilities and contractors to provide security training.

    E. It requires DoD facilities and contractors to enforce security policies.

12. Which is the purpose of a job task analysis?

    A. Identify pertinent skills

    B. Define the required knowledge

    C. Determine the amount of experience required

    D. To ensure that the job description is defensible in court

    E. All the above

13. A vendor-neutral certification is better than a vendor-specific certification.

    A. True

    B. False

14. Having a certification does not guarantee your level of competency in performing a job task or job function.

A. True

B. False

15. Which of the following is true about the CompTIA Security+ certification?

A. Globally recognized

B. Entry-level foundational certification

C. Requires a thorough understanding of security terms and definitions

D. Approved by the DoD for foundational, entry-level information systems security training

E. All the above

CHAPTER 15
Compliance Laws

EVERY DAY CYBERSPACE BRINGS NEW threats to U.S. citizens and organizations. People are sharing more and more data online to purchase goods and services, access desired information, and communicate with friends and colleagues; organizations collect and use an increasing amount of data to conduct business; and federal, state, and local governments collect and use information to provide services for their citizens.

With the increased collection of data comes questions about proper use of data. People, and an increasing number of legislative bodies, demand that the organizations entrusted with sensitive data take steps to protect their data. If the organizations do not voluntarily protect those data, people often say, "There ought to be a law." The United States does not have one comprehensive data protection law. Instead, many federal data protection laws focus on specific types of data. These laws are not optional; they require organizations to use security controls to protect the different kinds of data that they collect. Sometimes, organizations must follow several data protection laws. The chapter presents compliance laws that have been enacted during the past few decades and focuses on the security and privacy protection requirements required by those laws. It also introduces the international Payment Card Industry Data Security Standard (PCI DSS), which, though not a law, must be followed for any organizations that store, process, or transmit cardholder data (CHD).

Chapter 15 Topics

This chapter covers the following topics and concepts:

- What compliance is
- What the Federal Information Security Modernization Act (FISMA) is

- What the Health Insurance Portability and Accountability Act (HIPAA) is
- What the Gramm-Leach-Bliley Act (GLBA) is
- What the Sarbanes-Oxley Act (SOX) is
- What the Family Educational Rights and Privacy Act (FERPA) is
- What the Children's Internet Protection Act (CIPA) is
- What the PCI DSS is
- What the General Data Protection Regulation (GDPR) and California Consumer Privacy Act (CCPA) are
- How to make sense of information security compliance laws

Chapter 15 Goals

When you complete this chapter, you will be able to:

- Explain what compliance is and how it is related to information security
- Describe the main features of the FISMA
- Describe the main features of the HIPAA
- Describe the main features of the GLBA
- Describe the main features of the SOX
- Describe the main features of the FERPA
- Describe the CIPA
- Describe the requirements of the PCI DSS
- Describe how the GDPR and CCPA affect U.S. businesses

Compliance Is the Law

Organizations use and store a lot of data, and, for many organizations, data (i.e., information) is one of the most important assets that they use to conduct business. Moreover, they use large and complex databases (i.e., information technology [IT] systems) to keep track of customer product preferences and to manage the products and services that they offer their customers. Organizations also transfer data to other businesses. In addition, they often collect personal data that most people consider sensitive, known as **personally identifiable information (PII)**, which, as the name suggests, could allow organizations (or others) to identify a person. PII includes the following:

- First, middle, and last name
- Home mailing address
- Social Security numbers
- Driver's license numbers
- Financial account data, such as account numbers or personal identification numbers (PINs)
- Health data and biometric data
- Authentication credentials, such as logon or usernames and passwords

Sometimes, unfortunately, organizations do not do a very good job of protecting PII. For instance, they might lose the data, an event that the news headlines call a *data breach*. Moreover, they could use it in ways that their customers and clients did not approve. When organizations do not voluntarily protect PII, governments create laws that compel them to do so. Once the laws are enacted, the organizations must follow them; this is called **compliance**.

Compliance is an important legal concept defined as the act of following laws, rules, and regulations, but, for an organization, compliance involves not only following laws and regulations but also interpreting them so that policies and procedures can be defined. To comply with legal and regulatory

requirements, an organization must document policies, standards, procedures, or guidelines as part of its compliance activities. Moreover, it must be able to prove it is compliant in case of a lawsuit or litigation.

Organizations under a compliance law should do the following:

- Review the compliance law and its requirements
- Assign a designated compliance officer or individual responsible and accountable for the organization's compliance
- Create policies, standards, procedures, and guidelines to comply with legal and regulatory requirements
- Identify the organization's gaps in compliance and prioritize the gap remediation
- Implement proper security controls and countermeasures throughout the IT infrastructure in support of the compliance law's requirements
- Create and deliver annual security awareness training that educates employees about the organization's legal requirements for compliance

Compliance includes not only the actual state of being compliant but also the steps and processes taken to become compliant. Thus, the organization must answer the following questions: What are the rules? How must the rules be followed? Moreover, if an organization fails to meet its obligations, it can be subject to penalties.

TIP

If an organization is found to be out of compliance, going forward it must demonstrate proper due diligence and be able to prove that it is complying with laws and regulations every day. A starting point for any organization's compliance is for it to define and document policies, standards, procedures, and guidelines. Once documented, implementing these policies and procedures is required to demonstrate implementation maturity.

TIP

To ensure the confidentiality of sensitive data, organizations typically implement role-based access control mechanisms in their applications, such as masking, which is used to "X out" pertinent characters of sensitive data. For example, a 16-digit primary access number (PAN) would be masked as XXXX-XXXX-XXXX-1234, displaying only the last four numbers of the 16-digit credit card number. Full data encryption would make the sensitive data "unreadable" as follows: @#$2 – AAD8 – @#(+ – !@#D.

The United States does not have one comprehensive data protection law; instead, it has many laws that focus on different types of data found in different vertical industries. These laws contain privacy and information security concepts and requirements as well as focusing on how data can be used and must be protected. It is the job of several federal agencies to regulate compliance with these types of laws, which you will briefly learn about in the chapter. Be aware, though, that each one of these laws is long and detailed and would require more scrutiny than can be provided here. In fact, each one could easily be a book topic on its own. Later in the chapter, you will be introduced to the PCI DSS, which is the governing standard, though not an actual law, for how merchants and service providers are to store, process, or transmit cardholder data (CHD). **TABLE 15-1** lists the relevant laws and standards, the type of data they address, and the federal government authority or certification body that regulates compliance with them.

TABLE 15-1 Laws and standards that influence information security.

NAME OF LAW	INFORMATION REGULATED	REGULATING AGENCY

NAME OF LAW	INFORMATION REGULATED	REGULATING AGENCY
Children's Internet Protection Act (CIPA)	Internet access in certain schools and libraries	Federal Trade Commission (FTC)
Children's Online Privacy Protection Act of 1998 (COPPA)	Information collected from children under 13 years of age	FTC
Family Educational Rights and Privacy Act (FERPA)	Student educational records	U.S. Department of Education (DOE)
Federal Information Security Management Act of 2002 (FISMA)	Federal information systems	Office of Management and Budget (OMB)
Federal Information Security Modernization Act of 2014 (FISMA)	Federal information systems	OMB and U.S. Department of Homeland Security (DHS)
Gramm-Leach-Bliley Act (GLBA)	Consumer financial information	FTC
Health Insurance Portability and Accountability Act (HIPAA)	Protected health information	Department of Health and Human Services (HHS)
Payment Card Industry Data Security Standard (PCI DSS)*	Cardholder data: First and last name, 16-digit primary access number (PAN), three-digit authorization code (CVV), expiration date (MM/YY)	Payment card issuers: VISA, MasterCard, Discover, American Express, and JCB
Sarbanes-Oxley Act (SOX)	Corporate financial information	Securities and Exchange Commission (SEC)
NIST Special Publication 800-171	Controlled Unclassified Information in Nonfederal Systems and Organizations	National Institute of Standards and Technology (NIST)
General Data Protection Regulation (GDPR)	Consumer data for European Union citizens (regardless where that data travels)	European Union
California Consumer Privacy Act (CCPA)	Consumer data for California residents	State of California

* PCI DSS is an international standard, not a law.

As an information systems security professional, you must be familiar with the compliance laws that impact an organization. Your job is not to understand the legal implications of the law but rather know how that law impacts an organization and what you must do from an IT security

perspective. As an information systems security professional, you will be responsible for working with an organization's legal counsel, executive management, and IT organizations. Your key responsibility is to help bridge the gap between the compliance law's requirements and the organization's implementation of security controls to achieve compliance.

Federal Information Security

The federal government is the largest creator and user of information in the United States. Its IT systems contain data that is important for running the business of the federal government, including sensitive military data and very sensitive personal information about U.S. citizens.

The Federal Information Security Management Act of 2002

In 2002, Congress created the **Federal Information Security Management Act of 2002 (FISMA)**, which was created partly in response to the September 11, 2001, terrorist attacks, after which the government realized that the computer security for its IT systems was not what it should be. Therefore, FISMA, which applies to federal agencies and their IT systems, was passed to change the government's approach to information security. It superseded most of the federal government's previous computer security laws and, today, is the primary law that defines how federal agencies must secure their IT systems. The OMB is responsible for FISMA compliance.

Purpose and Main Requirements

FISMA defines *information security* as protecting federal agency IT systems to provide confidentiality, integrity, and availability. Agencies must protect their IT systems (and data in those systems) from unauthorized use, access, disruption, modification, and destruction.

FISMA requires each federal agency to create an agency-wide information security program that includes the following:

- **Risk assessments**—Agencies must measure the harm that could result from unauthorized access to or use of their IT systems by performing risk assessments. They then must base their information security programs on the results of these risk assessments.
- **Annual inventory**—Agencies must inventory their IT systems and then update the inventory each year.

- **Policies and procedures**—Agencies must create policies and procedures to reduce risk to an acceptable level as well as creating configuration management policies. The policies must protect IT systems throughout their life cycles.
- **Subordinate plans**—Agencies must make sure they have plans for securing networks, facilities, and systems or groups of IT systems. These plans are for technologies or system components that are a part of the larger information security program.
- **Security awareness training**—Agencies must train employees and any other users of their IT systems, including contractors, to make them aware of risks to the agency's IT systems as well as making them aware of their duties to protect these systems.
- **Testing and evaluation**—Agencies must test management, operational, and technical controls for each IT system at least once a year.
- **Remedial actions**—Agencies must have a plan to fix weaknesses in their information security programs.
- **Incident response**—Agencies must have an incident response procedure, within which they state how the agency detects and resolves incidents. Agencies must report incidents to the Department of Homeland Security (DHS).
- **Continuity of operations**—Agencies must have business continuity plans as part of their information security programs.

An agency's information security program applies to any other organization that uses the agency's IT systems or data. An agency must protect the IT systems that support its operations even if another agency or contractor owns the IT systems. This situation can broaden the scope of FISMA beyond a federal agency and is important because IT systems and functions are often outsourced. Systems security professionals must know whether any of their organization's IT systems use or process information belonging to federal agencies. If they do, then FISMA may apply.

One of the most important parts of a FISMA information security program is that agencies must test and evaluate it at least annually and test IT systems with greater risk more often. FISMA requires agencies to apply some types of controls, such as access control measures, and to review the information

security controls on these systems to ensure their controls work effectively. Annual testing recognizes that security is an ongoing process. Agencies must always monitor their security risk and the controls put in place to address that risk.

NOTE

Under FISMA, agencies must name a senior official in charge of information security, which, in most cases, is the chief information security officer (CISO). These officials must be information security professionals with security experience.

Each agency must report yearly to the OMB on its FISMA compliance work. The report must review the agency's information security program and assess the agency's progress on fixing any weaknesses in the program or security controls. Each agency then sends a copy of its report to certain congressional committees and other federal agencies. The OMB advises that agencies should not include too much information about actual IT system operations in their reports because it is possible that criminals could learn about weaknesses in federal IT systems by reading the reports.

The annual FISMA reporting process is time consuming, in that agencies spend a lot of time creating their reports and the OMB spends a lot of time reviewing them, as evidenced by the fact that it takes almost three full-time employees over a month to review the reports. The process is also very paper intensive. For example, in six years the Department of State spent $133 million to produce 95,000 pages of paper to meet its reporting requirements. To cut down on costs to produce the reports, in 2010 the OMB began requiring all federal agencies to file their reports electronically. Not only will the new electronic reporting tool reduce costs, but it will also allow agencies and the OMB to quickly assess the agency's information security posture.

The Federal Information Security Modernization Act of 2014

The **Federal Information Security Modernization Act of 2014 (FISMA)** was enacted in December 2014. The act formally assigned the DHS the responsibility for developing, implementing, and ensuring federal government-wide compliance as per FISMA information security policies, procedures, and security controls. FISMA 2014 does not introduce additional security requirements, but it does clearly define the roles, responsibilities, accountabilities, requirements, and practices that are needed to fully implement FISMA security controls and requirements.

The following list presents a summary of the changes to the FISMA 2002 legislation introduced in the FISMA 2014 legislation:

- DHS was anointed as the governing organization that is responsible for ensuring FISMA 2014 compliance, along with the OMB.
- Reporting requirements for U.S. federal government agencies were defined.
- New guidance and reporting requirements for security incidents were announced.
- Policies and guidelines were detailed for data breach notification compliance.

OMB is responsible for ensuring information security policies and practices and overseeing NIST's development of standards and guidelines, and DHS is leading the efforts to ensure that all U.S. federal government agencies conform to these new information security policies, standards, procedures, and guidelines. This separation of duties with FISMA 2014 is consistent with the OMB Memorandum M-10-28, which defines cybersecurity responsibilities between OMB and DHS.

Security incident response reporting and data breach notification are clearly defined in the FISMA 2014 legislation. FISMA 2014 defines a security incident as follows: "An occurrence that actually or imminently jeopardizes, without lawful authority, the integrity, confidentiality, or availability of information or an information system; or constitutes a violation or imminent threat or violation of law, security policies, security procedures, or acceptable use policies." In addition, each U.S. federal government agency is now required to report major incidents, within seven

days, to Congress and additional U.S. federal government officials in the OMB and/or the DHS.

NOTE

You can read the updated Federal Information Security Modernization Act of 2014 here: *www.cisa.gov/federal-information-security-modernization-act*.

The Role of the National Institute of Standards and Technology

To create information security standards and guidelines, both versions of FISMA rely on the U.S. Department of Commerce, which in turn delegated this duty to NIST, one of its agencies. NIST creates guidance that all federal agencies use for their information security programs, standards that agencies use to classify their data and IT systems, and guidelines and minimum information security controls for IT systems, all of which agencies must follow.

NIST creates two types of documents: Federal Information Processing Standards (FIPSs) and Special Publications (SPs), which are guidelines. Under FISMA, federal agencies must follow both FIPSs and SPs.

NOTE

Generally, a *standard* states mandatory actions that an organization must take to protect its IT systems, whereas a *guideline* states recommended actions that an organization should follow.

Non–federal entities also use SPs and FIPSs. For example, the Defense Federal Acquisition Regulation Supplement (DFARS), which is an extension

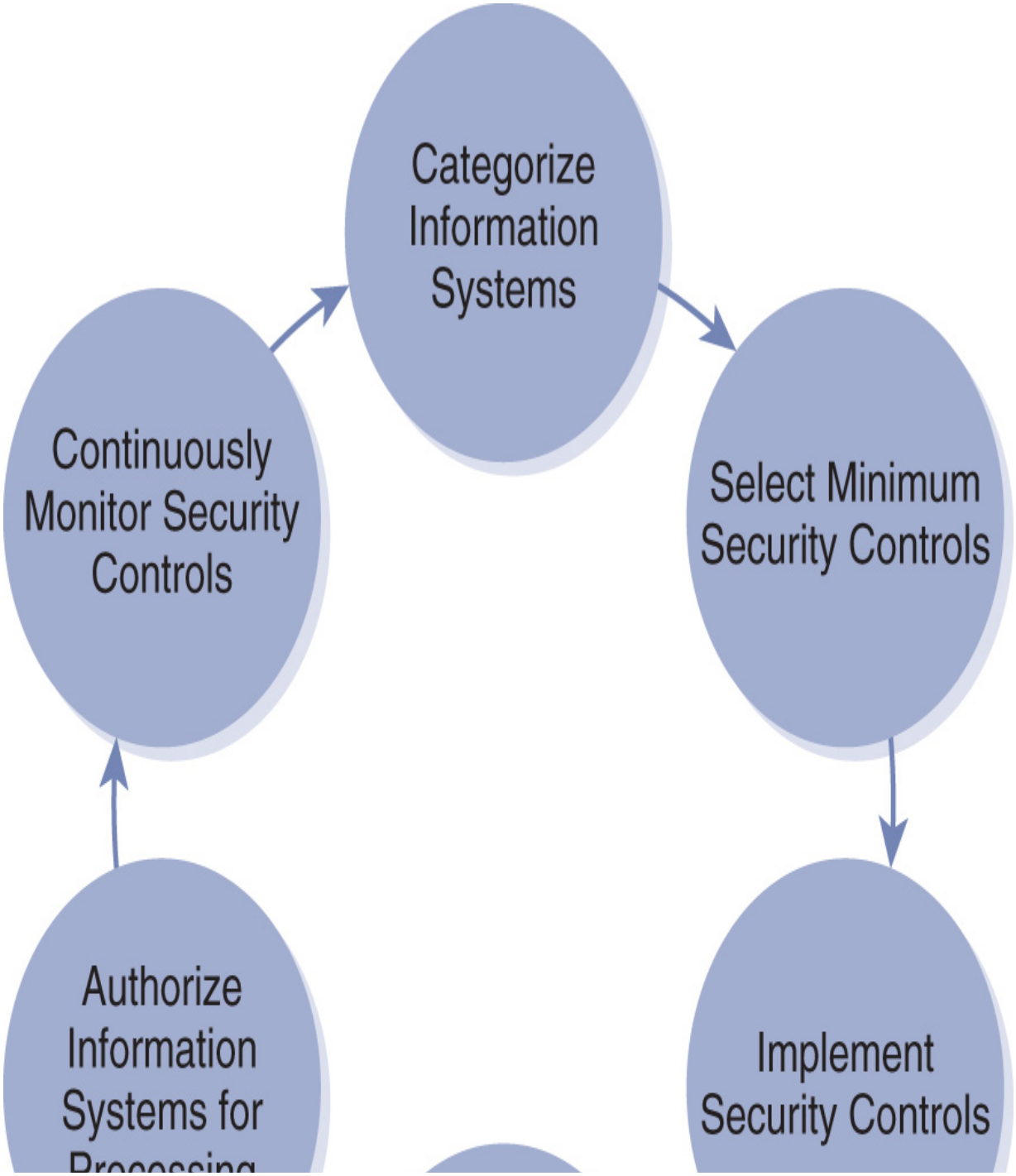
to the Federal Acquisition Regulation (FAR), sets standards for defense contractors for information security. Although federal agencies test their systems against NIST SP 800-53 controls, defense contractors can comply with FISMA by testing their systems against NIST SP 800-171 security controls. NIST SP 800-171 contains guidance for ensuring the confidentiality of controlled unclassified information (CUI) stored or processed on defense contractor information systems and provides specific guidance to assist defense contractors in complying with DFARS. Although NIST SP 800-171 is strictly recommendations, defense contractors must demonstrate adherence to it to qualify for contract acceptance in the defense industry supply chain. You can find details for NIST SP 800-171 Rev. 2 at *https://csrc.nist.gov/publications/detail/sp/800-171/rev-2/final*.

NIST also recommends using a risk management framework (RMF) approach for FISMA compliance. Government agencies that organize and prioritize risk can adopt an information systems security program to mitigate that risk. The NIST RMF outlines six steps to protect federal IT systems. These steps are as follows:

- **Categorize information systems**—An agency must sort its IT systems based on risk.
- **Select the minimum security controls**—An agency must select controls for its IT systems based on their risk category.
- **Implement security controls in IT systems**—An agency must apply controls in certain areas that are specified by NIST. Included in these areas are access control, contingency planning, and incident response.
- **Assess security controls for effectiveness**—An agency must assess its controls on a continuous basis to make sure that they are effective in reducing risk.
- **Authorize the IT system for processing**—An agency must test its IT systems and approve their operation and specifically accept the risks of operation before allowing a system to operate. This process used to be known in FISMA terminology as *certification and accreditation*.
- **Continuously monitor security controls**—An agency must monitor its security controls continuously to make sure they are effective. They also

must document any changes to their IT systems and assess the changes for new risks.

NIST's RMF recommends a continuous process of categorization and assessment as well as requiring continuous monitoring. **FIGURE 15-1** shows the RMF process.



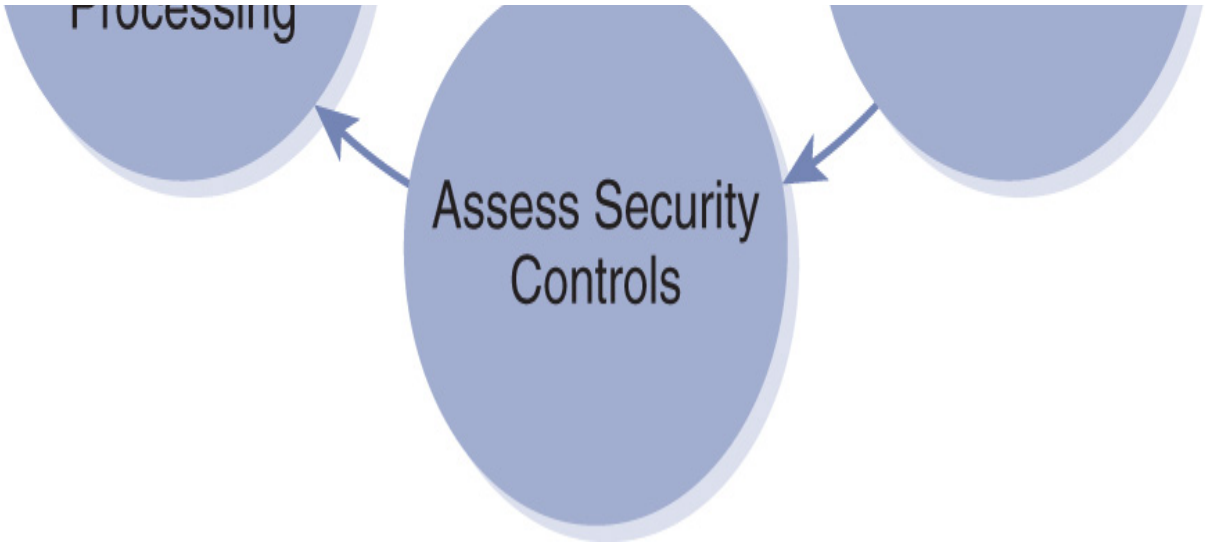


FIGURE 15-1 Risk management framework process.

National Security Systems

FISMA requires federal agencies to secure national security systems (NSSs) using a risk-based approach. These systems are used for the following purposes:

- Intelligence activities
- National defense
- Foreign policy
- Military activities

These systems must be specially protected due to their national security significance.

There are two regulatory entities that support and oversee FISMA activities: NIST, which creates programs that guide IT security and risk management activities, and DHS, which is responsible for implementing the programs that NIST creates.

The Health Insurance Portability and Accountability Act (HIPAA)

Most people consider their health information, which they share with health care providers to receive treatment, to be among the most sensitive types of personal information. Their medical records include details on illness diagnoses, lab results, treatment options, lifestyle, chronic conditions, or mental health counseling.

Many people fear that they will be embarrassed if their health data is not kept secret, and some even fear for their lives if particularly intimate facts, such as reasons for health counseling, are disclosed. Other people may fear that insurance companies or employers could reject them because of information in their health records.

People often feel that they have little control over how their health information is shared and protected. Almost every day media reports confirm that these are valid concerns. For example, in May 2020, Trinity Health System announced that one if its third-party vendors, Blackbaud, was the victim of a ransomware attack that resulted in the possible disclosure of private data from 3.3 million patients and donors, which represented the largest health data breach of 2020.

The federal government recognizes that health information is highly sensitive, and thus it created HIPAA to protect it.

Purpose and Scope

In 1996, Congress passed the **Health Insurance Portability and Accountability Act (HIPAA)**, which was subsequently amended in 2009 by the Health Information Technology for Economic and Clinical Health (HITECH) Act. HIPAA is best known for its data protection rules that address the security and privacy of personally identifiable health information. HHS makes these rules and oversees their compliance.

HIPAA applies to **protected health information (PHI)**, which is any individually identifiable information about a person's health. It includes past,

present, or future mental and physical health information and information about paying for health care. In short, PHI is commonly considered to be all information, in any form, that is put into a person's medical record.

Under HIPAA, covered entities may use PHI only in certain ways. The term **covered entity**, which is defined by the law, refers to very specific types of entities that must follow HIPAA. These entities include the following:

- Health plans
- Health care clearinghouses
- Any health care provider that transmits PHI in an electronic form

NOTE

PHI includes notes that your doctor puts in your medical record, any conversations your doctor has with anyone else about your health care, and billing information for health care goods and services provided to you. Information that your health insurance company has about your health care may also be PHI.

Determining which entities are covered under HIPAA can be complicated. Therefore, to help entities determine whether they are covered by HIPAA, HHS provides tools, which are available at *www.hhs.gov/hipaa/for-professionals/covered-entities/index.html*.

HIPAA also applies to the **business associates** of covered entities. A business associate is an organization to which a covered entity has outsourced a health care activity, such as claims and billing. Under the HITECH Act, HHS may directly require business associates to comply with HIPAA.

The HITECH Act, enacted as part of the American Recovery and Reinvestment Act of 2009, was designed to promote the widespread adoption and standardization of health information technology, which included electronic health record (EHR) systems. Providers that adopt EHR

systems can apply for meaningful use incentives to help pay for their transition to EHR platforms. Participation in federally funded programs such as the meaningful use program requires providers to maintain HIPAA Security and Privacy Rule compliance.

Main Requirements of the HIPAA Privacy Rule

Published in its final form by HHS in December 2000, the Privacy Rule determines how covered entities must protect the privacy of PHI. Compliance with the Privacy Rule was required in April 2003. The Privacy Rule represents the first time the U.S. government specified federal privacy protections for PHI.

Under the Privacy Rule, covered entities may not use or disclose people's PHI without their written consent. *Use* refers to the way a covered entity shares or handles PHI within its organization, and *disclosure* refers to the way a covered entity shares PHI with other organizations that may not be affiliated with it.

There are some exceptions to the Privacy Rule that allow a covered entity to share a person's PHI without that person's written consent. Because the main permitted use and disclosure of PHI under the Privacy Rule is for the entity's own treatment, payment, or health care operations and it is assumed that most people want their health care providers to use their PHI to provide medical treatment, a covered entity does not need a person's written consent to share PHI for this purpose. Treatment, payment, and health care operations are common covered-entity activities; therefore, requiring a person's written consent to complete these functions would be inefficient.

There are other times in which a covered entity may disclose PHI without consent, such as reporting victims of child abuse and neglect. Because the rules for disclosing PHI without consent are complicated, covered entities must analyze the rules carefully to make sure that they follow them.

Even if a covered entity is allowed to use or disclose PHI without written consent, it must follow the *minimum necessary rule*, which means that the covered entity may disclose only the amount of PHI necessary, and no more, to satisfy the reason for which the information is being used or disclosed. To do this, a covered entity must use its professional judgment and make reasonable efforts to limit the PHI's use or disclosure. In other words, a

health care provider should not disclose a person's entire medical record if only a portion of it is needed to respond to a request.

A covered entity must inform people about how it uses and discloses their PHI, which it does by issuing a privacy notice. This notice details the ways in which a covered entity is allowed to use and disclose PHI. Out of the many requirements for how these notices must be written, the most important is that a covered entity must use plain language to draft its notice, which means that an average person must be able to understand it.

Even though HIPAA's Privacy Rule requires covered entities to mitigate an unauthorized use or disclosure of PHI, it does not require them to notify people who have been affected by the breach of their PHI. Now, after the passage of the HITECH Act, they are required to do so. The act created notification requirements that covered entities must follow in the event of a breach of *unsecured* PHI. To be considered *secure*, PHI must be encrypted through an HHS-approved process.

Both covered entities and business associates must follow the many HIPAA breach notification rules. If a covered entity has a breach of unsecured PHI, it must notify the victims within 60 days of the discovery. A breach is "discovered" on the first day that the covered entity knows about it, and, subsequently, individuals must be notified without "unreasonable delay." A covered entity may delay notification if a law enforcement official requests it. Likewise, business associates are required to notify covered entities no later than 60 days following their discovery of a breach of unsecured PHI. Subsequently, they must help the covered entity notify victims.

NOTE

Under HIPAA, a *breach* is any impermissible use or disclosure of unsecured PHI that harms its security or privacy. Moreover, the use or disclosure must cause a significant risk of harm, either financial or reputational, to the affected person.

The Centers for Medicare & Medicaid Services, or CMS (*www.cms.gov*), tracks covered entities that have had a data breach or HIPAA violation assessed by HHS. In addition, CMS publishes and updates *RMH Chapter 08 Incident Response*, a manual for covered entities participating in federally funded programs. This document can be found at *www.cms.gov/Research-Statistics-Data-and-Systems/CMS-Information-Technology/InformationSecurity/Info-Security-Library-Items/RMH-Chapter-08-Incident-Response*.

Main Requirements of the HIPAA Security Rule

Since 2005, the HHS's Security Rule has required covered entities to protect the confidentiality, integrity, and availability of electronic PHI. This rule requires covered entities to use security safeguards to protect **electronic protected health information (ePHI)**, which is PHI that is stored in electronic form. Like the Privacy Rule, the Security Rule was the first time that the federal government had addressed security safeguards for electronic PHI. The rule requires covered entities to protect all ePHI they create, receive, or maintain as well as ePHI they transmit.

They must protect ePHI from reasonably anticipated threats and guard it from uses or disclosures that are not allowed by the Privacy Rule.

The Security Rule requires covered entities to create an information security program, for which they have flexibility in creating by being allowed to use various types of security technology. To create its program, the covered entity must consider the following:

- Its size and complexity
- Its technical infrastructure, hardware, and software security resources
- The costs of security measures
- The potential risks to ePHI

NOTE

An information security *safeguard* is also called an *information security control*. Laws often use these terms interchangeably because they mean the same thing.

The Security Rule also requires covered entities to protect ePHI by using administrative, physical, and technical safeguards that follow information security principles. Some safeguards are *required* (i.e., covered entities must implement them), and others are *addressable* (i.e., covered entities have discretion in implementing them). For addressable specifications, the entity must assess whether the control is reasonable and appropriate in its environment. If it is, the covered entity must use it, but, if it is not, the covered entity does not have to use it.

Half of the safeguards required by the Security Rule are administrative controls. They are actions, policies, and procedures that a covered entity must implement to follow the Security Rule. There are nine administrative safeguards. **TABLE 15-2** summarizes them.

TABLE 15-2 Security Rule administrative safeguards.

SAFEGUARD	REQUIRED SPECIFICATIONS	ADDRESSABLE SPECIFICATIONS
Security Management Process	Risk analysis Risk management Sanction policy Information system activity review	
Name an Official Responsible for Security Rule Compliance	Required	
Workforce Security Measures to Protect ePHI		Authorization and/or supervision Workforce clearance procedure Termination procedures

SAFEGUARD	REQUIRED SPECIFICATIONS	ADDRESSABLE SPECIFICATIONS
ePHI Access Management	Isolating health care clearinghouse function	Access authorization
		Access establishment and modification
Security Awareness and Training		Security reminders
		Protection from malicious software
		Logon monitoring
		Password management
Security Incident Procedures	Response and reporting	
Contingency Plan	Data backup plan	Testing and revision procedure
	Disaster recovery plan	Applications and data criticality analysis
	Emergency mode operation plan	
Evaluation of Security Safeguards Program	Required	
Business Associate Contracts and Other Arrangements	Written contracts or other arrangements	

Physical safeguards are controls put in place to protect a covered entity's physical resources. They protect information systems, equipment, and buildings from environmental threats. The Security Rule contains four physical security standards. **TABLE 15-3** summarizes the required and addressable physical safeguards required by the Security Rule.

TABLE 15-3 Security Rule physical safeguards.

SAFEGUARD	REQUIRED SPECIFICATIONS	ADDRESSABLE SPECIFICATIONS

SAFEGUARD	REQUIRED SPECIFICATIONS	ADDRESSABLE SPECIFICATIONS
Facility Access Controls		Contingency operations
		Facility security plan
		Access control and validation procedures
		Maintenance records
Workstation Use	Required	
Workstation Security	Required	
Device and Media Controls	Disposal	Accountability
	Media reuse	Data backup and storage

Technical safeguards are applied in the hardware and software of an information system. The Security Rule contains five technical security standards. **TABLE 15-4** summarizes the required and addressable technical safeguards required by the Security Rule.

TABLE 15-4 Security Rule technical safeguards.

SAFEGUARD	REQUIRED SPECIFICATIONS	ADDRESSABLE SPECIFICATIONS
Access Control	Unique user identification Emergency access procedure	Automatic logoff
		Encryption and decryption
Audit Controls	Required	
Integrity		Mechanism to authenticate ePHI
Person or Entity Authentication	Required	
Transmission Security		Integrity controls Encryption

Oversight

HHS oversees compliance with the HIPAA Privacy and Security Rules. It delegated this function to its Office for Civil Rights (OCR), which enforces the rules for both covered entities and business associates and investigates

and responds to complaints from people who claim that a covered entity has violated HIPAA. The OCR can levy fines on a covered entity that is in violation of HIPAA Security or Privacy Rule compliance. The HITECH Act defined a tiered system for assessing the level of each HIPAA privacy violation and, therefore, its penalty as follows:

NOTE

Information about the OCR complaint process is available at *www.hhs.gov/ocr/privacy/hipaa/complaints/index.html*.

- **Tier A**—Violations for which offenders did not realize that they were violating the act and would have handled the matter differently if they had. Each violation results in a $100 fine, not to exceed $25,000 per calendar year.
- **Tier B**—Violations due to reasonable cause but not "willful neglect." Each violation results in a $1,000 fine, not to exceed $100,000 per calendar year.
- **Tier C**—Violations due to willful neglect that the organization ultimately corrected. Each violation results in a $10,000 fine, not to exceed $250,000 per calendar year.
- **Tier D**—Violations of willful neglect that the organization did not correct. Each violation results in a $50,000 fine, not to exceed $1,500,000 per calendar year.

Omnibus Regulations

In January 2013, the Omnibus Rule was released, providing a catchall update to HIPAA and the HITECH Act rulings. The Omnibus Rule tightens the requirements of covered entities and business associates in the following capacities:

- Modification to the standard for reporting breaches of unsecured PHI

- Extension of HHS enforcement authority over business associates
- Expansion of the definition of the term *business associate* to include health information organizations, e-prescribing gateways, entities that provide data transmission services for PHI and that require routine access to such PHI, and personal health record vendors
- Modifications to the requirements for business associate agreements
- New obligations for business associates to enter into business associate agreements
- Removal of limitations on the liability of covered entities for the acts and omissions of business associates
- Changes to the requirements for notices of privacy practices
- New limitations on the sale of PHI
- New limitations on and clarifications concerning the use and disclosure of PHI for marketing
- Relaxation of certain limitations on the use of PHI for fundraising
- Improvement to the regulations concerning authorizations for the use or disclosure of PHI for research

The Gramm-Leach-Bliley Act

According to the Verizon *2020 Data Breach Investigations Report*, during 2019, more than 3,905 known data breaches occurred. Leading the pack of breaches in identified industries at 11 percent of all breaches in the 2020 report were financial organizations.

Consumer financial information is PII that a person provides to a vendor to get a good or service, including services from banks or other financial institutions. These institutions collect and use this data to provide home or car loans, approve credit cards, or open checking accounts, and consumers demand that it be protected.

The **Gramm-Leach-Bliley Act (GLBA)** addresses the privacy and security of consumer financial information. GLBA, also known as the Financial Services Modernization Act of 1999, made great changes in the banking industry. Its main purpose was to allow banks, securities, and insurance companies to merge, something that was not allowed before the passage of GLBA. The financial industry urged Congress to pass GLBA so that customers could use one company for all their financial service needs.

After the implementation of the GLBA, these new, larger corporations had access to large amounts of consumer financial information, and people feared that their privacy would suffer. To help ease that fear, Congress included privacy and security protections in GLBA, which act like the HIPAA rule that mandated both privacy and security requirements.

Acting in concert with the GLBA is the **Federal Financial Institutions Examination Council's (FFIEC's)** regulatory committee, which services the U.S. banking community. The FFIEC is a formal interagency body responsible for defining and prescribing uniform principles, standards, and report forms for the federal examination of financial institutions by the Board of Governors of the Federal Reserve Board (FRB), the Federal Deposit Insurance Corporation (FDIC), the National Credit Union Administration (NCUA), the Office of the Comptroller of the Currency (OCC), and the Consumer Financial Protection Bureau (CFPB). In 2006, the State Liaison Committee (SLC) was added to the FFIEC to address state-chartered banks.

The SLC includes members appointed by the Conference of State Bank Supervisors (CSBS), the American Council of State Savings Supervisors (ACSSS), and the National Association of State Credit Union Supervisors (NASCUS).

The FFIEC developed a Cybersecurity Assessment Tool that banks and financial institutions could use to determine their cybersecurity maturity. The assessment tool consists of two parts:

- Inherent Risk Profile
- Cybersecurity Maturity

The Inherent Risk Profile assesses the following categories:

- Technologies and Connection Types
- Delivery Channels
- Online/Mobile Products and Technology Services
- Organizational Characteristics
- External Threats

The organization's executive management must then evaluate the organization's cybersecurity maturity level for each of the following domains:

- Cyber Risk Management and Oversight
- Threat Intelligence and Collaboration
- Cybersecurity Controls
- External Dependency Management
- Cyber Incident Management and Resilience

By examining an organization's Inherent Risk Profile and Cybersecurity Maturity across all the domains, an organization's management can assess whether gap remediation and hardening are required to lower the risk impact while increasing the organization's overall cybersecurity posture. FFIEC is used to complement a banking or financial organization's ongoing risk management program and cybersecurity implementations.

In the *Consumer Sentinel Network Data Book*, the FTC tracks consumer complaints for identity theft, fraud, and other consumer-related scams, such as Ponzi schemes. Every year the FTC releases a report about fraud and identity theft based on complaints to its Consumer Sentinel Database. You can download the latest annual report at *www.ftc.gov /enforcement/consumer-sentinel-network/reports*.

Purpose and Scope

The GLBA applies to consumer financial activities only, which are transactions made for personal, family, or household services, such as borrowing, lending, credit counseling, debt collection, or similar activities; it does not apply to business transactions. Because of their vulnerability to fraud, financial institutions must follow the GLBA privacy and security rules to help mitigate data breaches and identity theft. Any institution that engages in these activities must follow the GLBA rules.

The GLBA requires financial institutions to protect consumers' **nonpublic personal information (NPI)**, which is PII in either paper or electronic form that a consumer shares with a financial institution during a financial transaction. NPI also includes PII that an institution gets from sources other than the consumer. Under the GLBA, NPI includes the following:

- Social Security number
- Financial account numbers
- Credit card numbers
- Date of birth
- Name, address, and phone numbers when collected with financial data
- Details of any transactions or the fact that an individual is a customer of a financial institution

NOTE

NPI does not include a consumer's publicly available information, for example, a person's address in a phone book.

Compliance with the GLBA can be tricky to maintain. It is a complicated law that is administered by several federal agencies that have GLBA oversight responsibilities, based on the type of financial institution under review. Following are the agencies with GLBA oversight responsibilities:

- **Securities and Exchange Commission (SEC)**—Oversees securities brokers and dealers
- **Federal Reserve System (the Fed)**—Oversees state-chartered member banks and bank holding companies
- **Federal Deposit Insurance Corporation (FDIC)**—Oversees state-chartered banks that are not members of the Fed
- **National Credit Union Administration (NCUA)**—Oversees federally insured credit unions
- **Office of the Comptroller of the Currency (OCC)**—Oversees nationally chartered banks
- **Office of Thrift Supervision (OTS)**—Oversees all nationally chartered and some state-chartered thrifts
- **Federal Trade Commission (FTC)**—Oversees the GLBA for any financial institution that is not regulated by one of the other agencies

Main Requirements of the GLBA Privacy Rule

All the GLBA regulatory agencies worked together to create the GLBA Privacy Rule, which went into effect July 1, 2001. Under this rule, a financial institution may not share a consumer's NPI with nonaffiliated third parties. A financial institution can share this information only when it first provides the consumer with notice of its privacy practices. This notice must tell consumers about the types of data that the institution collects, how the institution uses the collected information, and how the institution protects a consumer's NPI. The Privacy Rule requires that consumers have a chance to opt out of certain types of data sharing with nonaffiliated third parties.

The GLBA distinguishes between customers and consumers for its notice requirements. A *consumer* is any person who gets a consumer financial product or service from a financial institution, whereas a *customer* is a consumer who has a continuing relationship with the institution. An example of consumers without a customer relationship is people who withdraw cash from an ATM that does not belong to their personal bank. They are consumers of the bank's ATM service but are not customers of that bank. Customers must receive the financial institution's privacy notices. A financial institution does not have to give a privacy notice to a consumer if it does not share the consumer's NPI with nonaffiliated parties.

An institution must give a customer notice of its privacy practices as soon as the customer relationship begins. Customers also must receive a copy of the privacy notice each year for as long as the relationship continues. The notice must be provided in writing and be understandable.

NOTE

Nonaffiliated parties are entities that are not legally related to a financial institution, whereas *affiliated parties* do have a legal relationship in that they are members of the same corporate family. Affiliated parties are any entities that control, are controlled by, or are under the common control of another entity, whereas nonaffiliated parties do not have these legal relationships with one another.

Financial institutions must give their privacy notice to consumers if they plan to share the consumers' NPI with nonaffiliated parties and must give the consumers a chance to stop them from sharing that information. This is called an *opt-out provision*. The privacy notice must tell consumers how to opt out. If a consumer does not opt out, the financial institution can share NPI in ways described by its privacy notice.

The GLBA does not give consumers the right to opt out of situations where a financial institution shares NPI with its affiliates. In some instances,

consumers do not have the ability to opt out at all. For example, consumers cannot opt out of a disclosure that is required by law.

Main Requirements of the GLBA Safeguards Rule

The GLBA, under the Safeguards Rule, requires the agencies that regulate financial institutions to issue security standards for those institutions to follow. The law requires each agency to create security standards that do the following:

- Protect the security and confidentiality of customer data
- Protect against threats to the security or integrity of customer data
- Protect against unauthorized access to or use of customer data that could result in harm to a customer

Unlike with the Privacy Rule, the agencies with GLBA oversight responsibilities did not work together to create one Safeguards Rule. The SEC issued its rule in June 2000; the Fed, FDIC, NCUA, OCC, and OTS worked together to issue a joint rule in early 2001; and the FTC issued its Safeguards Rule in May 2002. These rules are all very similar to one another. For simplicity's sake, this section refers to the FTC Safeguards Rule.

The FTC Safeguards Rule requires a financial institution to create a written *information security program*, which must state how the institution collects and uses customer data and must describe the controls used to protect that data. Financial institutions must use administrative, technical, or physical controls, and the program must protect information in paper and electronic forms.

The Safeguards Rule allows financial institutions some flexibility in that it does not have general security program requirements that all institutions must follow. Instead, it requires financial institutions to have programs that are a good fit for their size and complexity and are suitable for the sensitivity of the customer data that the institution uses. The level of protection depends on the sensitivity of the data. The rule also requires institutions to do the following:

- Assign an employee to run the program
- Conduct a risk assessment to identify risks to customer information
- Assess current safeguards to make sure they are effective
- Design and implement safeguards to control risks
- Select service providers and make sure that contracts with them include terms to protect customer information
- Review the information security program regularly to account for changes in business

The Safeguards Rule allows financial institutions to pick the controls that best protect customer data. It specifies three areas that institutions must review for their programs:

- Employee management and training
- Information systems design
- Detecting and responding to attacks and system failures

Institutions must be sure to address these areas when conducting their risk assessments and in their information security programs.

Oversight

The agencies that oversee GLBA compliance may act against the financial institutions that they regulate when those institutions violate the GLBA. Such institutions can be subject to both criminal and civil penalties, and monetary fines can be substantial.

The GLBA requires financial institutions to follow the Privacy and Security Rules. Thus, security professionals who work for financial institutions or those that engage in financial activities must know about these rules to make sure that the organizations' IT systems operate in a way that complies with the law.

The Sarbanes-Oxley Act

Many large corporate scandals occurred in the early 2000s, such as Enron, Adelphia, and WorldCom, all of which made news for their inaccurate and misleading financial reporting practices. These practices duped investors by making the corporations look more successful than they were, and as a result many of them, including corporate employees, lost large amounts of money because, by the time everyone knew the truth, it was too late to recover investment losses. When these scandals came to light, they shook investor confidence in the U.S. economy, which resulted in some of the worst stock market performance ever in the decade from 2000 to 2009.

Accurate information is the "investor's best tool" so people can invest wisely and make money. Because investors have a hard time detecting fraud, in 2002 Congress passed the Public Company Accounting Reform and Investor Protection Act, more commonly known as the **Sarbanes-Oxley Act of 2002**, or SOX or Sarbox for short, to help protect them. On July 30, 2002, President George W. Bush signed SOX into law, at which time he called SOX "the most far-reaching reforms of American business practices since the time of Franklin Delano Roosevelt."

Purpose and Scope

The main goal of SOX is to protect investors from financial fraud by supplementing other federal securities laws that apply to only publicly traded, not privately held, companies that must register with the SEC. Investors own a publicly traded company by buying its stock on a stock exchange.

Even though SOX is a very detailed act with many provisions, Congress did not mention IT anywhere within it; therefore, most companies assumed that the act did not have any IT components. However, this opinion changed as companies began to study SOX more carefully. Because many SOX provisions require companies to verify the accuracy of their financial information and IT systems hold many types of financial information, companies and auditors quickly realized that these systems were part of SOX

compliance, which meant that the way those systems are used and the controls used to safeguard those systems had to be reviewed for SOX compliance.

NOTE

The two most popular U.S. stock exchanges are the New York Stock Exchange (NYSE) and the NASDAQ Stock Market. National securities exchanges are registered with the SEC. You can learn more at *www.sec.gov/fast-answers/divisionsmarketregmrexchanges.html*.

The relationship between IT and SOX compliance continues to evolve. This section focuses on SOX Section 404 certification requirements. Section 404 requires an organization's executive officers to establish, maintain, review, and report on the effectiveness of the company's internal controls over financial reporting (ICFR); thus, to make these certifications, an organization's executives must understand how the organization's IT systems work.

SOX Control Certification Requirements

SOX Section 404 requires a company's executive management to report on the effectiveness of the company's ICFR by making a certification on documents that the company files with the SEC. The certification helps to ensure that the company's financial reports are accurate, which in turn helps protect investors from fraudulent financial activities.

To make this certification to the SEC, a company must create, document, and test its ICFR, which it must report on every year. After a company makes its yearly report, outside auditors must review it to verify that the ICFR specified in the report work.

Under SEC rules, ICFR are processes that provide reasonable assurance that an organization's financial reports are reliable. The ICFR processes

provide management with reasonable assurance of the following:

- Financial reports, records, and data are accurately maintained.
- Transactions are prepared according to accounting rules and are properly recorded.
- Unauthorized acquisition or use of data or assets that could affect financial statements will be prevented or detected in a timely manner.

Companies that were trying to comply with Section 404 quickly learned that they needed to review their IT systems, specifically, the ICFR on their IT systems. IT systems that contain financial data require attention to ensure deployed controls meet SOX requirements. An error in these systems could cause financial statements to contain errors or mistakes. Therefore, to comply with Section 404, companies must ensure that their systems data is accurate and demonstrate that they have processes in place to detect inaccurate data.

Because Section 404 is very general about the types of ICFR that companies must implement—it does not give a good definition for ICFR generally, and it does not address IT controls at all—companies found that complying with SOX Section 404 was difficult. Thus, in response to many complaints about the large scope of a Section 404 review, in 2007 the SEC issued additional guidance to help companies assess their ICFR during their Section 404 review. Many of these complaints focused on how to address IT controls.

The SEC stated two broad principles in its guidance:

- Management should assess how its internal controls prevent or detect significant deficiencies in financial statements.
- Management should perform a risk-based review of the effectiveness of these controls.

NOTE

SOX does not specify the IT controls that companies need to implement. Instead, companies must determine the best controls for their systems.

The SEC also said that management must exercise its professional judgment to limit the scope of a Section 404 review. It reminded companies that SOX applies to internal controls, including IT controls, that affect financial reporting only, which means that a Section 404 review certainly applies to IT systems that process financial data but might not apply to IT systems that process nonfinancial data.

Management must review general IT controls to make sure that IT systems operate properly and consistently and that they have reasonable assurance that the IT systems operate properly to protect financial reporting. **TABLE 15-5** shows how the goals of ICFR match up with information security goals.

TABLE 15-5 Internal controls and information security goals.

STEPS TAKEN TO MEET INTERNAL CONTROLS	INFORMATION SECURITY GOALS
Financial reports, records, and data are accurately maintained.	Integrity
Transactions are prepared according to generally accepted accounting principles (GAAP) rules and properly recorded.	Integrity, availability
Unauthorized acquisition or use of data or assets that could affect financial statements will be prevented or detected in a timely manner.	Confidentiality, integrity, availability

Companies cannot escape SOX Section 404 liability by outsourcing their financial functions because SOX still requires them to monitor the ICFR for outsourced operations. Many companies do this by asking their outsourcing companies to provide them with a special audit report about the outsourced operations, which they must review to determine whether the outsourcing company's controls are sufficient.

SOX Records Retention Requirements

SOX contains provisions for records retention, which systems security professionals must know about because most companies store many of their records electronically. In fact, some studies estimate that 93 percent of all business documents are created and stored electronically. Because

companies must understand how their IT systems work to meet SOX retention requirements, the systems security professional is instrumental in helping organizations understand how to manage and secure their electronic records.

SOX requires public companies to maintain their financial audit papers (i.e., the materials that support the conclusions made in an audit report) for seven years. The type of records that must be saved include work papers, memoranda, and correspondence as well as any other records created, sent, or received in connection with the audit, including electronic records.

Furthermore, SOX requires that a public company permanently retain the records and documentation that it uses to assess its ICFR. Guidance issued by the SEC recognizes that this documentation takes several forms, including electronic data.

The penalties for failing to retain records for the prescribed amount of time can be severe. SOX makes it a crime for a person or company to violate its records retention provisions knowingly and willfully. A person who violates this provision can face fines and up to 10 years in prison.

Oversight

Most SOX provisions are overseen and enforced by the SEC, which was created under the Securities and Exchange Act of 1934, with the mission of protecting investors and maintaining the integrity of the securities industry. The SEC has the power to investigate and sanction public companies that do not comply with SOX. Even though the SEC has discretion in deciding how often to review companies, SOX requires it to review a public company's yearly and quarterly reports at least once every three years for the purpose of detecting fraud and inaccurate financial statements that could harm the investing public.

The SEC has five commissioners, appointed by the U.S. president, who serve for five-year terms, and no more than three of the commissioners may belong to the same political party. The SEC has 11 regional offices in the United States.

FYI

Many federal and state laws, including SOX, contain records retention requirements. Therefore, organizations should develop document retention policies to help them track their various obligations.

The Family Educational Rights and Privacy Act

Educational institutions, such as colleges, universities, and grade schools, have access to large amounts of information about their students. They can collect and store the following types of student data:

- Demographic information
- Address and contact information
- Parental demographic information
- Parental address and contact information
- Grade information
- Disciplinary information

All this data is useful to educational institutions in educating students and is very sensitive. Thus, privacy concerns are raised if an educational institution improperly discloses this information to third parties because its release could be embarrassing for the student and the student's family. The **Family Educational Rights and Privacy Act (FERPA)** is the main federal law protecting the privacy of student information.

Purpose and Scope

Congress created FERPA in 1974. It applies to any education agency or institution that receives federal funding. Educational institutions include the following:

- Community colleges
- Colleges and universities
- Primary and secondary schools (kindergarten through 12th grade)
- State and local educational agencies (such as a school board)
- Schools or agencies offering a preschool program
- Any other educational institution that receives federal funding

This section collectively refers to these educational institutions as *schools*. Because most schools receive federal funding from the U.S. Department of Education, they must comply with FERPA, and, because federal funding is very important to most schools, most of them comply. Some small private schools do not receive federal funds, and therefore they do not have to comply with FERPA.

FERPA is a very detailed act with many provisions whose primary goal is to protect the privacy of student records. A *student record* includes any data about a student that a school keeps in either paper or electronic form. These records include written documents, computer media, video, film, and photographs as well as any records maintained by an outside party acting on a school's behalf.

Even though FERPA does not require that specific information security controls be implemented to protect student records, systems security professionals must be aware of FERPA's requirements. If an organization is an educational institution or maintains records for a school, FERPA may apply to the data it uses, which means that the organization must then implement security controls in IT systems to protect the privacy of electronic student records.

FYI

The FERPA definition for PII is different from the generic definition for PII that has been used throughout this section. When you read any law, you must always be sure to check how that law defines specific terms because, sometimes, a word's legal definition can be very different from its generic definition.

Main Requirements

Under FERPA, students (or their parents if the student is under 18) have the following rights:

- The right to know what data is in the student's student record and the right to inspect and review that record
- The right to request that a school correct errors in a student record
- The right to consent to have certain kinds of student data released

A school must protect its student records, especially the PII that is in the records. Under FERPA, PII includes *direct identifiers*, such as a student's name, Social Security number, and student number, as well as *indirect identifiers*, which are personal characteristics that can be used to easily identify a student.

Generally, a school cannot release a student's records to a third party without the student's written consent, but there are exceptions. For example, without the student's written consent, school officials can view student records when required by their job duties; schools can transfer students' records from an old to a new school or for financial aid or accreditation purposes; or schools can disclose students' information to comply with a court order or lawful subpoena.

FERPA allows a special category of PII to be disclosed without student consent. A school can do this if it has given notice to the student that it will disclose this information. This category of information is called directory information, which is information that is publicly available about all students (e.g., a student's name, address, or telephone number). Many schools give out this information, and colleges and universities often provide this type of information in an online directory. Even though a school can release directory information without a student's consent, the student can choose to forbid the release of this type of information by informing the school not to release this type of information. If a student tells a school not to release directory information, the school must put measures in place to make sure that this information is not released.

FERPA requires schools to give students and parents an annual notice about the school's FERPA practices. This notice informs students and parents about their FERPA rights. It tells students about the school officials who have access to records without student consent. For example, FERPA allows any official (e.g., teachers, instructors, professors, or administrative personnel, such as principals or provosts) who has a legitimate educational interest in

the school record to view it without the student's consent. Moreover, the school must identify these officials.

NOTE

For more information about your FERPA privacy rights as a student or parent, visit *www2.ed.gov/policy/gen/guid/fpco/ferpa/index.html*.

IT and information systems security professionals who work for higher education institutions must also comply with FERPA. Typically, schools share student privacy data, which includes PII and transcript grades, when students are transferring or applying for graduate school. IT departments within higher education institutions are responsible and accountable for maintaining the confidentiality of student privacy data.

Oversight

The Family Policy Compliance Office (FPCO) oversees FERPA compliance and has the authority to review and investigate FERPA complaints. Schools that violate FERPA can lose their federal funding. Students who have had their FERPA rights violated are not allowed to sue a school for that violation. Only the FPCO is allowed to sanction schools that violate FERPA.

The Children's Online Privacy Protection Act of 1998

The purpose of the **Children's Online Privacy Protection Act of 1998 (COPPA)** is to restrict the online collection of personal information of children under 13 years of age. The legislation specifies the following:

- What a website operator must include in a privacy policy
- When to pursue verifiable consent from a parent or guardian, and how that consent can be acquired
- Responsibilities a website operator has to protect children's privacy and safety online, including restrictions on marketing activities to individuals under the age of 13

The FTC reports that courts may fine violators of COPPA up to $43,280 in civil penalties for each violation.

In December 2012, the FTC issued revisions to COPPA that became effective on July 1, 2013. These revisions created additional parental notice and consent requirements, amended definitions, and added other obligations for organizations that either (1) operate a website or online service that is "directed to children" under 13 and that collects "personal information" from users or (2) knowingly collects personal information from children under the age of 13 through an online service.

The Children's Internet Protection Act

The purpose of the **Children's Internet Protection Act (CIPA)** is to protect children from exposure to offensive Internet content. Not every public school system or public library must comply with CIPA, only those that participate in the E-Rate federal funding program, which provides discounts to most primary and secondary schools and libraries for Internet access. Discounts range from 20 to 90 percent of the actual costs, but schools and libraries do not have to accept these funds. They can either pay for the Internet access with private funds or choose not to use the Internet. The Federal Communications Commission (FCC) manages the E-Rate program.

Purpose and Scope

Congress passed CIPA in 2000. It requires certain schools and libraries to filter offensive Internet content so that children cannot not access it. CIPA defines a minor as anyone under the age of 17. Offensive content includes any visual depictions that are obscene, child pornography, or harmful to minors (if the computers are accessed by minors). CIPA defines the phrase "harmful to minors" as any visual picture that:

- Appeals to a prurient interest in nudity, sex, or excretion with respect to what is suitable for minors
- Depicts, describes, or represents sexual acts, contact, or genitalia in a patently offensive way with respect to what is suitable for minors
- Taken as a whole, lacks serious literary, artistic, political, or scientific value with respect to what is suitable for minors

NOTE

The law refers to anyone who is not of legal adult age as a minor. A minor is a child. Different laws may state different ages for determining

when people are minors and when they are not.

CIPA was quickly challenged by the American Library Association and the American Civil Liberties Union, both of which claimed that CIPA violated the free speech rights of adults and that the law could prevent minors from getting information about topics such as breast cancer. A federal court agreed that CIPA violated free speech rights and temporarily overturned CIPA in 2002.

The government then appealed the decision of the federal court to the U.S. Supreme Court in *United States et al. v. American Library Association, Inc. et al*. In 2003, the Supreme Court overturned the lower court and upheld the law, stating that only schools and libraries that receive E-Rate funding for Internet access must comply with CIPA and that a school or library can choose not to accept the funding. The case also specifically held that CIPA applies to minors only. Therefore, schools and libraries must have some way to allow adults unfiltered Internet access. If they do not, they face scrutiny for censorship and violating the First Amendment rights of the adult.

NOTE

The First Amendment of the U.S. Constitution sets forth the right to freedom of religion, speech, the press, and assembly. Within these rights is the implicit right of freedom of thought, which has a privacy component. Censorship actions can violate the First Amendment.

Main Requirements

Schools and libraries can use technological tools to meet the CIPA requirement that covered schools and libraries must filter offensive Internet content so that children cannot get to it. CIPA identifies these tools as a **technology protection measure (TPM)**, which is any technology that can

block or filter the objectionable content, an example of which is a proxy server used to filter content.

Even though the FCC recognizes that a TPM cannot be 100 percent effective, neither it nor CIPA defines what level is acceptable. Therefore, a third-party company may claim that its filter is CIPA compliant even though no certification process exists to verify that claim. The FCC has stated that local authorities should determine which measures are most effective for their community.

CIPA states what must be filtered but not how to filter it. In addition to the TPM, the school or library must create an Internet safety policy and identify a method for addressing filtering exceptions.

NOTE

The use of proxy servers is not restricted to CIPA compliance; many companies use them for various purposes. For example, they can be used to restrict employees' access to particular Internet websites.

To comply with CIPA, schools and libraries must adopt and enforce an Internet safety policy that includes provisions for monitoring children's online activity. It must state how the school or library will restrict access to objectionable online materials as well as addressing the safety and security of children when they are using email, chat rooms, or other electronic communications; situations in which a child uses the Internet for unlawful activities; and the unauthorized use of a child's personal information.

Under CIPA, an important point to remember is that a library or school must be able to disable the TPM for any adult who needs to use a computer. Failure to do so puts schools or libraries at risk of violating adults' First Amendment rights, which guarantees them the right to use the system without any filtering.

To disable the TPM, libraries can use any method that works best for them. For example, library personnel could disable the TPMs on some computers, label them as "for adults only," and then prevent minors from

using them. They could log on with the proper credentials to a program designed to disable the TPM or require an administrator to disable the TPM upon request by a patron.

Oversight

Even though the FCC has oversight for CIPA, little oversight action is required. When public schools or libraries request E-Rate funding, they must certify that they comply with CIPA, which is usually all that is required.

If a TPM fails, the school or library is expected to take steps to resolve the failure. If the library does not resolve it, a patron can file a complaint with the FCC. If the FCC receives complaints that too many objectionable images are getting through, it may investigate.

The FCC presumes that Congress never intended libraries to be fined if they do not comply with CIPA. At most, the FCC may require a library to refund the E-Rate discount for the period during which it was not in compliance.

Payment Card Industry Data Security Standard

Credit card data breaches are top of mind in today's news headlines. Someone or some organization is getting breached right now, whether via identity theft, an actual data breach, or a data compromise. Five major international credit card brands (i.e., American Express, Discover, JCB, MasterCard, and Visa) formed the Payment Card Industry Security Standards Council (PCI SSC) in 2006 to share in defining the governance and execution of the council's standards for ensuring the confidentiality, integrity, and availability of cardholder data and transaction-processing functions.

Purpose and Scope

The PCI SSC has two major priorities. Priority number one is to assist merchants and financial institutions in understanding and implementing standards for security policies, technologies, and ongoing processes that protect their payment systems from breaches and theft of cardholder data. Its second priority is to help vendors understand and implement the PCI standards and requirements for ensuring secure payment solutions are properly implemented.

The latest version of the **Payment Card Industry Data Security Standard (PCI DSS)** is v3.2.1 as of this writing. This standard addresses security matters; PCI compliance requirements; securing the IT infrastructure; and performing ongoing security risk assessments, security testing, and annual verification that specific risk management functions are being performed, such as annual security awareness training for all employees.

NOTE

Access the PCI SSC homepage at *www.pcisecuritystandards.org*. For specific information about PCI DSS v3.2.1, go to *www.pcisecuritystandards.org/document_library?category=pcidss*

&document=pci_dss. The same page provides a link to view a summary of the differences between v3.2 and v3.2.1.

TABLE 15-6 presents the PCI DSS requirements for compliance. These requirements are organized into groups called control objectives.

TABLE 15-6 PCI DSS requirements.

CONTROL OBJECTIVES	PCI DSS REQUIREMENTS
Build and maintain a secure network	1. Install and maintain a firewall configuration to protect cardholder data
	2. Do not use vendor-supplied defaults for system passwords and other security parameters
Protect cardholder data	3. Protect stored cardholder data
	4. Encrypt transmission of cardholder data across open, public networks
Maintain a vulnerability management program	5. Use and regularly update antivirus software on all systems commonly affected by malware
	6. Develop and maintain secure systems and applications
Implement strong access control measures	7. Restrict access to cardholder data by business need to know
	8. Assign a unique ID to each person with computer access
	9. Restrict physical access to cardholder data
Regularly monitor and test networks	10. Track and monitor all access to network resources and cardholder data
	11. Regularly test security systems and processes
Maintain an information security policy	12. Maintain a policy that addresses information security

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SSC, its programs or materials, please contact PCI SSC through its web site at https://www.pcisecuritystandards.org

To validate compliance, all merchants and service providers, regardless of credit card transaction volume and acceptance channel, must fulfill two validation requirements. Some merchants and service providers validate compliance through an annual onsite PCI audit, performed by a **qualified security assessor (QSA)**, a certified professional who passed a certification exam. In addition, quarterly vulnerability assessment scanning must be performed by an **approved scanning vendor (ASV)**. This requires the company to perform patch remediation before rescanning to verify a passing grade. Other organizations are required to complete an annual **self-assessment questionnaire (SAQ)** and quarterly vulnerability assessment scanning performed by an ASV.

TABLE 15-7 depicts the PCI compliance requirements for merchants at the various tier levels, and **TABLE 15-8** depicts the PCI compliance requirements for service providers at the various tier levels. A tier-level designation is determined by aggregating the annual credit card transaction volume total. Once that is determined, the merchant or service provider tier level can be identified.

TABLE 15-7	PCI DSS merchant tier levels.

TIER	CRITERIA	ONSITE SECURITY AUDIT	SELF-ASSESSMENT QUESTIONNAIRE	NETWORK SCAN	VALIDATED THIRD-PARTY PAYMENT APPLICATION
1	Any merchant, regardless of acceptance channel, processing more than 6 million transactions per year Any merchant that suffered a security breach resulting in an account compromise	Required annually (requires a QSA, ROC, and AOC)		Required quarterly	Required
2	Any merchant processing between 1 and 6 million transactions per year	Required annually (requires an ROC and AOC)		Required quarterly	Required
3	Any merchant processing between 20,000 and 1 million transactions per year		Required annually	Required quarterly	Required
4	All other merchants not in Levels 1, 2, or 3, regardless of acceptance channel		Required annually	Required quarterly	Required

TABLE 15-8 PCI DSS service provider tier levels.

TIER	CRITERIA	ONSITE SECURITY AUDIT	SELF-ASSESSMENT QUESTIONNAIRE	NETWORK SCAN	VALIDATED THIRD-PARTY PAYMENT APPLICATION
1	All processors and all payment gateways	Required annually (requires a QSA, ROC, and AOC)		Required quarterly	Required
2	Any service provider that is not in Level 1 and that stores, processes, or transmits more than 1 million accounts/transactions annually	Required annually (requires an ROC and AOC)		Required quarterly	Required
3	Any service provider that is not in Tier 1 and that stores, processes, or transmits less than 1 million accounts/ transactions annually		Required annually	Required quarterly	Required

NOTE

The annual onsite security audit requires that a **report of compliance (ROC)** be completed. The ROC is needed such that an **attestation of compliance (AOC)** can be completed and signed by the CEO and the QSA who performed the actual PCI compliance audit (e.g., ROC) and filled in the AOC. The AOC is what holds CEOs accountable for PCI compliance for their organizations.

Self-Assessment Questionnaire

The SAQ lists all the security control requirements that are needed for the various SAQ levels. The type of SAQ that an organization must use is based on the methods or types of credit card transactions that are performed by that

organization. **TABLE 15-9** depicts what each credit card transaction method or type requires from an SAQ compliance perspective.

TABLE 15-9 SAQ is determined by the processing type of the credit card transaction.

S A Q	DESCRIPTION
A	Card-not-present merchants (e-commerce or mail/telephone orders) that have fully outsourced all cardholder data functions to PCI DSS validated third-party service providers, with no electronic storage, processing, or transmission of any cardholder data on the merchant's systems or premises. *Not applicable to face-to-face channels.*
A-EP	E-commerce merchants that outsource all payment processing to PCI DSS–validated third parties and that have a website(s) that does not directly receive cardholder data but that can impact the security of the payment transaction. No electronic storage, processing, or transmission of any cardholder data on the merchant's systems or premises. *Applicable only to e-commerce channels.*
B	Merchants using imprint machines with no electronic cardholder data storage and/or stand-alone, dial-out terminals with no electronic cardholder data storage. *Not applicable to e-commerce channels.*
B-IP	Merchants using only stand-alone, PIN Transaction Security (PTS)–approved payment terminals with an Internet Protocol (IP) connection to the payment processor, with no electronic cardholder data storage. *Not applicable to e-commerce channels.*
C-VT	Merchants who manually enter a single transaction at a time via a keyboard into an Internet-based virtual terminal solution that is provided and hosted by a PCI DSS–validated third-party service provider. No electronic cardholder data storage. *Not applicable to e-commerce channels.*
C	Merchants with payment application systems connected to the Internet. No electronic cardholder data storage. *Not applicable to e-commerce channels.*
P2PE-HW	Merchants using only hardware payment terminals that are included in and managed via a validated, PCI SSC–listed point-to-point encryption (P2PE) solution, with no electronic cardholder data storage. *Not applicable to e-commerce channels.*
D	*SAQ D for Merchants*: All merchants not included in descriptions for the above SAQ types. *SAQ D for Service Providers*: All service providers defined by a payment brand as eligible to complete an SAQ.

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General Data Protection Regulation

In 2016, the European Union (EU) implemented a far-reaching regulation to protect consumer data privacy called the **General Data Protection Regulation (GDPR)**, which strictly controls how personal data of EU citizens is collected, stored, used, and retired. Although the GDPR is an EU regulation, it affects non–EU organizations that do business with EU citizens. The purpose of the GDPR is to give consumers complete control of their personal data, including when their data gets deleted. One of the more challenging requirements of the GDPR is the "right to be forgotten," which means that EU citizens can demand to have their data completely removed at any time. Complying with the GDPR has resulted in many global organizations rethinking their privacy policies.

California Consumer Privacy Act

The U.S. State of California passed the **California Consumer Privacy Act (CCPA)** in 2018 to protect consumer private data of California residents. The CCPA, also known as Proposition 24, was signed into law on October 11, 2019, and became effective on January 1, 2020. The CCPA shares many aspects of the GDPR and is sometimes referred to as "GDPR lite." The main goal of the CCPA, like that of the GDPR, is to give control of private data back to the data owner—the consumer.

Making Sense of Laws for Information Security Compliance

The United States does not have just one data protection law. As a result, many laws focus on different types of data. The chapter focused specifically on federal data protection laws, but you must remember that states have data protection laws too. A discussion of all the different kinds of state data protection laws could consume a book in itself. Just remember that organizations must comply with federal laws *and* laws of the states in which they are located. When systems security professionals work on compliance projects, they must be aware of both kinds of laws.

Because IT systems can hold many different types of data, it is possible that an organization will need to make sure that its systems are compliant with several laws. As a result, an organization's information security program must be comprehensive so that it can accommodate a general response to many laws. To do this, systems security professionals must understand what each law has in common from an information security standpoint.

For example, many of the laws discussed in the chapter require an organization to assess the security of its IT systems. To do this, the organization must perform a risk assessment, something that is a stated requirement of many laws, such as FISMA, GLBA, HIPAA, SOX, GDPR, and CCPA, and for which systems security professionals are often responsible. Performing a risk assessment helps organizations identify where their IT systems are vulnerable and allows the organization to take steps to reduce the identified risks. The process of performing a risk assessment and taking steps to reduce risk is known as *risk management*.

System security professionals are in a unique position because they must appreciate the impact these laws and regulations have on how IT systems operate as well as how the basic tenets of information security influence these laws. Almost all the laws discussed here focus on protecting the confidentiality of certain types of data, such as FISMA, HIPAA, GLBA,

FERPA, GDPR, and CCPA. Information security is not just a good idea; it's the law.

Some of the laws have integrity requirements, such as FERPA, HIPAA, GDPR, and CCPA, all of which require organizations to have a way to identify inaccurate data as well as being able to correct it. SOX requires that organizations test and certify the internal controls on their IT systems. These controls must protect financial data from being modified without proper authorization.

Other laws have availability requirements. CIPA requires that certain types of online materials be available to one population (adults) but denied to another population (children), which is an availability concept. An organization will need to use access control measures to comply with CIPA. FISMA requires federal agencies to create contingency plans for their IT systems, and HIPAA has a similar requirement. These plans ensure that IT systems are available during and after an incident or disaster. Even if a law does not specifically address availability, it is an important requirement for almost every organization. The GDPR and CCPA also include availability requirements. Organizations need their data and IT systems to be available to conduct business.

TABLE 15-10 shows how you can think about the laws discussed in the chapter with respect to information security concepts.

TABLE 15-10 Laws and information security concepts.

CONFIDENTIALITY	INTEGRITY	AVAILABILITY
FISMA	FISMA	FISMA
HIPAA	HIPAA	HIPAA
GLBA	SOX	GLBA
FERPA	FERPA	SOX
		CIPA
PCI DSS v3.2.1*	PCI DSS v3.2.1*	PCI DSS v3.2.1*
GDPR	GDPR	GDPR
CCPA	CCPA	CCPA

* PCI DSS is an international standard, not a law.

As a systems security professional, you will possess the skills needed to make sense of these compliance laws and understand how IT systems must be configured to meet an organization's compliance requirements. Moreover, you will be able to explain how these laws affect IT systems and the steps that an organization took to be compliant with these laws.

NOTE

Contingency plans include incident response and disaster recovery plans.

CHAPTER SUMMARY

The chapter presented U.S. compliance laws in various vertical industries. These laws have a security component, a privacy component, or both. Organizations that operate within any of these vertical industries are mandated to comply with the federal laws. Organizations must document their compliance with these laws and be able to prove they have done so if they are audited.

Because of these compliance laws, information systems security professionals are busy with translating the legal requirements into tactical security implementation as well as implementing security controls throughout the IT infrastructure. Protecting confidential information, such as privacy data, requires implementation of proper security controls.

The PCI DSS standard, although not a law, must be followed by PCI merchants and service providers that either store, process, or transmit cardholder data. The PCI has specific requirements for ensuring the confidentiality, integrity, and availability of cardholder data used for performing credit card transaction processing. How an organization processes credit card transactions defines which SAQ it must abide by, and the number of annual credit card transactions defines the organization's merchant or service provider tier level. The EU's GDPR and California's CCPA ushered in a completely new era in protecting consumer privacy.

KEY CONCEPTS AND TERMS

Approved scanning vendor (ASV)
Attestation of compliance (AOC)
Business associate
California Consumer Privacy Act (CCPA)
Children's Internet Protection Act (CIPA)
Children's Online Privacy Protection Act (COPPA)
Compliance
Covered entity
Electronic protected health information (ePHI)
Family Educational Rights and Privacy Act (FERPA)
Federal Financial Institutions Examination Council (FFIEC)
Federal Information Security Management Act of 2002 (FISMA)
Federal Information Security Modernization Act of 2014 (FISMA)
General Data Protection Regulation (GDPR)
Gramm-Leach-Bliley Act (GLBA)
Health Insurance Portability and Accountability Act (HIPAA)
Miller test
Nonpublic personal information (NPI)
Payment Card Industry Data Security Standard (PCI DSS)
Personally identifiable information (PII)
Protected health information (PHI)
Qualified security assessor (QSA)
Report of compliance (ROC)
Sarbanes-Oxley Act of 2002
Self-assessment questionnaire (SAQ)
Technology protection measure (TPM)

CHAPTER 15 ASSESSMENT

1. An addressable HIPAA security rule citation requirement must be implemented if it is _____ for an environment.
2. What elements must a written GLBA information security program include?
   A. Technical safeguards
   B. Physical safeguards
   C. Administrative safeguards
   D. A designated employee to run the program
   E. All the above
3. What types of companies must follow all Sarbanes-Oxley Act provisions?
   A. Public
   B. Private
   C. Nonprofit
   D. Governmental
   E. None of the above
4. CIPA requires a library to be able to disable the TPM for some situations.
   A. True
   B. False
5. What law governs the release of student information?
   A. HIPAA
   B. SOX
   C. FERPA
   D. CIPA
   E. None of the above
6. What is the maximum yearly fine for a violation of the HIPAA Privacy or Security Rule?
   A. $100
   B. $1,500

C. $1 million
D. $1.5 million
E. It is unlimited.

7. The United States has one comprehensive data protection law.
   A. True
   B. False
8. What must an educational institution get before releasing student personal information to a third party?
   A. Verbal consent
   B. Notarized consent
   C. Signed affidavit
   D. Written consent
   E. None of the above
9. Who is considered a “minor” under CIPA?
   A. Anyone under the age of 13
   B. Anyone under the age of 17
   C. Anyone under the age of 20
   D. Anyone under the age of 21
   E. None of the above
10. What is personally identifiable information?
    A. First and last name
    B. Date of birth
    C. Social Security number
    D. Home address
    E. All the above
11. FISMA requires federal agencies to test their information security controls at least annually.
    A. True
    B. False
12. What is the main goal of the PCI Security Standards Council?
    A. Define a standardized approach for protecting cardholder data
    B. Recommend firewall solutions
    C. Define how to process credit cards

D. Mandate organizations follow a standard to protect cardholder data
E. None of the above

13. Which PCI DSS merchant tier level(s) requires an onsite annual audit that must be performed by a certified QSA professional?
    A. 1
    B. 2
    C. 3
    D. 4
    E. Both A and B
14. Of the following laws, which one was the first to address privacy and security of consumer financial information?
    A. HIPAA
    B. GDPR
    C. CCPA
    D. GLBA
    E. FISMA
15. Companies that have customers who are European Union citizens must abide by which regulation?
    A. CCPA
    B. FISMA
    C. GLBA
    D. SOX
    E. GDPR

APPENDIX A
Answer Key

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CHAPTER 1 Information Systems Security

1. A 2. A 3. C 4. A 5. B 6. E 7. E 8. D 9. A 10. A 11. A 12. A 13. E 14. D 15. B

CHAPTER 2 Emerging Technologies Are Changing How We Live

1. A 2. E 3. A 4. E 5. E 6. E 7. B 8. A 9. A 10. E 11. B 12. C

CHAPTER 3 Risks, Threats, and Vulnerabilities

1. A 2. E 3. B 4. packet sniffer 5. A 6. A 7. D 8. D 9. A 10. C 11. C 12. B

CHAPTER 4 Business Drivers of Information Security

1. B 2. A 3. B 4. E 5. B 6. D 7. E 8. A 9. A 10. D 11. C 12. E 13. HIPAA 14. A 15. E

CHAPTER 5 Networks and Telecommunications

1. C 2. A 3. B 4. A 5. D 6. Router 7. B 8. A 9. C 10. B 11. A 12. B 13. B 14. D 15. D

CHAPTER 6 Access Controls

1. A 2. D 3. B 4. A 5. C 6. A 7. B 8. B 9. D 10. B 11. E 12. B 13. A 14. D

CHAPTER 7 Cryptography

1. C 2. A 3. B 4. D 5. A 6. A 7. A 8. E 9. A 10. A 11. D 12. A

CHAPTER 8 Malicious Software and Attack Vectors

1. B 2. Spam 3. C 4. A 5. B 6. D 7. B 8. B 9. C 10. B 11. D 12. defense-in-depth 13. A

CHAPTER 9 Security Operations and Administration

1. A 2. D 3. B 4. C 5. B 6. B 7. D 8. E 9. A 10. B 11. B 12. A 13. E 14. A 15. D 16. A 17. E 18. B

CHAPTER 10 Auditing, Testing, and Monitoring

1. A 2. E 3. B 4. C 5. E 6. A 7. A 8. C 9. A 10. B 11. B 12. D

CHAPTER 11 Contingency Planning

1. C 2. A 3. A 4. A 5. C 6. E 7. A 8. D 9. B 10. C

CHAPTER 12 Digital Forensics

1. A 2. C. 3. C 4. B 5. D 6. A 7. C 8. B 9. C 10. D

CHAPTER 13 Information Security Standards

1. A 2. B 3. A 4. D 5. TCP/IP 6. Request for comments (RFCs)7. A 8. IEEE 9. D 10. B

CHAPTER 14 Information Security Certifications

1. A 2. C 3. B 4. D 5. CIW 6. A 7. E 8. B 9. A 10. D 11. A 12. E 13. B 14. A 15. E

CHAPTER 15 Compliance Laws

1. Reasonable and appropriate 2. E 3. A 4. B 5. C 6. D 7. B 8. D 9. B 10. E 11. A 12. A 13. A 14. D 15. E

APPENDIX B
Standard Acronyms

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3DES Triple Data Encryption Standard
ACK acknowledgment
ACL access control list
AES Advanced Encryption Standard
ANSI American National Standards Institute

AP	access point
API	application programming interface
AUP	acceptable use policy
B2B	business to business
B2C	business to consumer
BBB	Better Business Bureau
BCP	business continuity plan
BIA	business impact analysis
BYOD	bring your own device
CA	certificate authority
CASB	cloud access security broker
CBF	critical business function
CCC	CERT Coordination Center
CCNA	Cisco Certified Network Associate
CCPA	California Consumer Privacy Act
CIPA	Children's Internet Protection Act
CISA	Certified Information Systems Auditor
CISM	Certified Information Security Manager
CISSP	Certified Information System Security Professional
COPPA	Children's Online Privacy Protection Act
DBMS	database management system
DDoS	distributed denial of service
DES	Data Encryption Standard
DMZ	demilitarized zone
DoS	denial of service
DPI	deep packet inspection
DRP	disaster recovery plan
DSL	digital subscriber line
DSS	Digital Signature Standard
DSU	data service unit
EDI	Electronic Data Interchange
EIDE	Enhanced IDE
ePHI	electronic protected health information
ETSI	European Telecommunications Standards Institute
EULA	end-user license agreement
FACTA	Fair and Accurate Credit Transactions Act
FAR	false acceptance rate
FBI	Federal Bureau of Investigation
FDIC	Federal Deposit Insurance Corporation
FEP	front-end processor
FERPA	Family Educational Rights and Privacy Act

FFIEC Federal Financial Institutions Examination Council

FISMA Federal Information Security Management Act; Federal Information Security Modernization Act

FRCP Federal Rules of Civil Procedure

FRR false rejection rate

FTC Federal Trade Commission

FTP File Transfer Protocol

GDPR General Data Protection Regulation

GIAC Global Information Assurance Certification

GLBA Gramm-Leach-Bliley Act

HIDS host-based intrusion detection system

HIPAA Health Insurance Portability and Accountability Act

HIPS host-based intrusion prevention system

HOTP HMAC-based one-time password

HTML Hypertext Markup Language

HTTP Hypertext Transfer Protocol

IAB Internet Architecture Board

IAM identity and access management

ICMP Internet Control Message Protocol

IDEA International Data Encryption Algorithm

IDPS intrusion detection and prevention system

IDS intrusion detection system

IEC International Electrotechnical Commission

IEEE Institute of Electrical and Electronics Engineers

IETF Internet Engineering Task Force

InfoSec information security

IPS intrusion prevention system

IPSec IP security

IPv4 Internet Protocol version 4

IPv6 Internet Protocol version 6

IRS Internal Revenue Service

IRT incident response team

(ISC)^2 International Information System Security Certification Consortium

ISO International Organization for Standardization

ISP Internet service provider

ISS Internet security systems

ITRC Identity Theft Resource Center

ITU International Telecommunication Union

IVR interactive voice response

LAN local area network

MAN metropolitan area network

MFA multifactor authentication
modem modulator demodulator
NAC network access control
NAT network address translation
NFIC National Fraud Information Center
NIDS network intrusion detection system
NIPS network intrusion prevention system
NIST National Institute of Standards and Technology
NMS network management system
NVD National Vulnerability Database
OS operating system
OSI open system interconnection
PBX private branch exchange
PCI Payment Card Industry
PGP Pretty Good Privacy
PII personally identifiable information
PKI public key infrastructure
RAID redundant array of independent disks
RBAC role-based access control
RFC Request for Comments
RSA Rivest, Shamir, and Adleman (algorithm)
SAN storage area network
SANCP Security Analyst Network Connection Profiler
SANS SysAdmin, Audit, Network, Security
SAP service access point
SCSI small computer system interface
SDLC software development life cycle
SET secure electronic transaction
SGC server-gated cryptography
SHA Secure Hash Algorithm
S-HTTP secure HTTP
SIEM security information and event management
SLA service level agreement
SMFA specific management functional area
SNMP Simple Network Management Protocol
SOC security operations center; Security Organization Controls
SOAR security, orchestration, automation, and response
SOX Sarbanes-Oxley Act of 2002 (also Sarbox)
SSA Social Security Administration
SSCP Systems Security Certified Practitioner
SSL Secure Sockets Layer

SSL/TLS	Secure Sockets Layer/Transport Layer Security
SSO	single system sign-on
STP	shielded twisted cable
TCP/IP	Transmission Control Protocol/Internet Protocol
TCSEC	Trusted Computer System Evaluation Criteria
TFTP	Trivial File Transfer Protocol
TNI	trusted network infrastructure
TOTP	time-based one-time password
UDP	User Datagram Protocol
UPS	uninterruptible power supply
USB	universal serial bus
UTP	unshielded twisted pair cable
VLAN	virtual local area network
VPN	virtual private network
W3C	World Wide Web Consortium
WAN	wide area network
WEP	wired equivalent privacy
Wi-Fi	wireless fidelity
WLAN	wireless local area network
WNIC	wireless network interface card
WPA	Wi-Fi protected access
WWW	World Wide Web
XSS	cross-site scripting
XSRF	cross-site request forgery

APPENDIX C

Earning the CompTIA Security+ Certification

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Why Choose InfoSec as a Career

Improving cybersecurity has often been a management directive that lagged behind most other areas of focus, but that is changing. Improving cybersecurity is becoming more and more important while it is becoming clear that the pool of trained security personnel is insufficient to meet the need. The 2019 $(ISC)^2$ Global Information Security Workforce Study estimates a shortfall of 4 million trained security personnel. Now is a great time to enter the InfoSec domain and be part of the solution.

InfoSec professionals hold positions ranging from security practitioner to chief information officer, and the average salary for an experienced, certified information security professional can exceed $100,000 USD per year. And because information security is an international problem, these skills are in demand worldwide. The following sections give you a few tips for getting started.

NOTE

You can download and read the complete 2019 $(ISC)^2$ Global Information Security Workforce Study at *www.isc2.org/-/media/ISC2/Research/2019-Cybersecurity-Workforce-Study/ISC2-Cybersecurity-Workforce-Study-2019.ashx*.

Break into the Information Security Field

Get educated—If you choose a career in information security, specialized education will be necessary to address the evolving threats to information systems. The weaknesses and threats that have been witnessed for many years are still valid today—hacking, worms, viruses, data theft, and corruption—but new threats continue to develop—mobile security, cloud computing, software/application, and social media vulnerabilities.

Pursue a certification—Of course, most students and recent graduates will not have the experience necessary to acquire the most elite certifications, but, after gaining some practical experience, more

certifications become available. A great place to start is to pursue an entry-level security certification, such as the CompTIA Security+ certification. The Security+ certification is vendor neutral and often separates the holder from other entry-level candidates being considered for employment opportunities. It shows that you have taken the time to acquire the breadth of knowledge necessary to operate in the information security domain.

Gain experience—The right education and certification are important, but experience is paramount. Experience deepens your practical knowledge in multiple areas and qualifies you for more elite certifications. By obtaining one or more globally recognized elite certifications, you will prove your knowledge, skills, and abilities in information systems security, giving you the edge among your competition.

Consider the CompTIA Security+ to Help Start Your Career

The CompTIA Security+ certification is a technical certification that does not require any level of experience. However, CompTIA does recommend that candidates have at least two years of related IT administration experience and hold the Network+ certification. The Security+ certification is for the hands-on practitioner who continuously monitors information systems to safeguard against security threats while having the knowledge to apply security concepts, tools, and procedures to react against security incidents. This certification is geared toward individuals who may hold or are working toward technical and engineering-related information security positions as well as nonsecurity-specific information technology positions. For example, you could be working as a network security engineer, systems security analyst, or security administrator. This certification could also be a good option for those working in an information technology position that requires an understanding of security concepts and best practices. Such nonsecurity-related positions could include system administrators, application programmers, database administrators, and systems analysts. The certification's focus is on the technical aspects of information security and on the design, implementation, and administration of information systems in

compliance with stated policies. To add to the Security+ certification's value, it is also approved by the U.S. Department of Defense to meet Directive 8140/8570.1-M requirements. If you want to pursue employment in a government position in information security, a certification that satisfies Directive 8140/8570.1-M requirements will be a big help.

Due to rapidly emerging technologies, the exam objectives of the Security+ certification will continue to evolve, which is why CompTIA periodically updates its exam. This certification exam addresses today's information security concerns, such as mobile computing, cloud computing, risk management, software security, business continuity planning, and how to recover from a disaster.

The five domains of the CompTIA Security+ exam covered by this textbook follow:

- 1.0 Attacks, Threats, and Vulnerabilities
- 2.0 Architecture and Design
- 3.0 Implementation
- 4.0 Operations and Incident Response
- 5.0 Governance, Risk, and Compliance

Why Certification Is Important

The vast majority of hiring managers globally and in the United States state that their biggest hiring challenges are finding candidates with the right skills and level of experience. Employers understand that candidates holding a certification such as the Security+ have proven their knowledge in the field of information security. They do not have to sift through a résumé to uncover knowledge. Of course, they look for the experience that accompanies the certification, but that is sometimes hard to offer when you are applying for your first job. And it is acknowledged that certain certification holders earn an average of at least 20 percent more than information security practitioners/professionals who do not hold a certification.

When you are making your decision on which certification(s) to pursue, it is important to plan ahead. Here are some things you should consider:

- Is the certification technology or vendor specific? Can the tested skills apply to any type of environment?
- Is the certification globally recognized? If you want to apply for jobs internationally, how can you be sure that an employer appreciates your skills?
- Many organizations and government agencies require their candidates to be certified; does the certification you are considering meet their needs?
- After you have earned your first certification and you want to progress down your career path, are other certifications available that will help you in your journey?
- Does holding the certification present you with more educational opportunities to help ensure that your skills are always up to date?
- Does the certifying body provide its members with free or low-cost global events and networking opportunities?

About CompTIA

The Computing Technology Industry Association (CompTIA) is a nonprofit trade association formed in 1982 to offer education and vendor-neutral professional certifications for the information technology industry. CompTIA offers a wide range of certifications in addition to the Security+ certification. Other popular CompTIA certifications include A+ (computer technician), IT Fundamentals (ITF+), Network+, Advanced Security Practitioner (CASP+), Cybersecurity Analyst (CySA+), PenTest+, Cloud Essentials+, Server+, Certified Technical Trainer (CTT+), Linux+, Project+, and Cloud+. For more information on CompTIA, visit *www.comptia.org/*.

Glossary of Key Terms

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A

Acceptable use policy (AUP) | An organization-wide policy that defines what is allowed and disallowed regarding use of IT assets by employees and authorized contractors.

Access control | The process of protecting a resource so that it is used only by those allowed to use it; a particular method used to restrict or allow access to resources.

Access control list (ACL) | An implementation technique to control access to a resource by maintaining a table of authorized user IDs; also used to permit or deny IP packets to/from router and

switch interfaces to managed IP traffic flow.

Access control policy | An organizational policy definition that defines how authorized users gain access to resources based on their role and job functions and duties. This policy defines the rules for how employees and authorized contractors are granted access and how their access is removed.

Accountability | Defining the roles and responsibilities of key IT security employees and incident response team members and what they must do.

Accounting | The process of recording audit trails and events in log files when monitoring access controls to information systems and applications.

Accreditation | The formal acceptance by the authorizing official of the risk of implementing the system.

Accredited | (1) Formally recognized as meeting specific basic requirements. (2) From an educational perspective, an organization that has successfully undergone evaluation by an external body to determine whether the organization meets applicable standards.

Acquisition | The process of collecting evidence.

Action | An activity that authorized users can perform using IT assets, systems, applications, and data.

Active content | Refers to components, primarily on websites, that provide functionality to interact with users.

Activity phase control | Security control that can be either technical or administrative and is classified as follows:

- Preventive control exists to prevent the threat from encountering the weakness.
- Detective control exists to identify that the threat has landed in a system.
- Corrective control exists to mitigate or lessen the effects of the threat being manifested.

Address Resolution Protocol (ARP) | ARP is used to map an IP address to a physical or MAC address.

Administrative control | A set of parameters involved in the process of developing and ensuring compliance with policy and procedures.

Admissibility | The determination that evidence is either acceptable or unacceptable to a court of law.

Adware | A software program that collects information about Internet usage and uses it to present targeted advertisements to users.

Agile development | A method of developing software that is based on small project iterations, or sprints, instead of long project schedules.

Algorithm | A mathematical process or formula for performing some kind of math function.

American National Standards Institute (ANSI) | A U.S. standards organization whose goal is to empower its members and constituents to strengthen the U.S. marketplace position in the global

economy while helping to ensure the safety and health of consumers and the protection of the environment.

Annualized rate of occurrence (ARO) | How often a loss is likely to occur every year; also called likelihood. The annualized loss expectancy (ALE) is the product of this rate and the single loss expectancy (SLE). It is mathematically expressed as $ALE = ARO \times SLE$.

Anomaly-based IDS | An intrusion detection system that compares current activity with stored profiles of normal (expected) activity.

Antivirus | Software designed to detect and mitigate some types of malware, including mainly viruses, worms, and Trojan horses.

Anything as a Service (AaaS) | A new technology offering a solution that is hosted by a third-party vendor typically within a cloud infrastructure. By hosting within a cloud infrastructure, a one-to-many delivery solution can be supported. This type of delivery solution allows for a recurring revenue model where the customer pays a monthly fee for the use of the technology, hardware, or software solution.

Application attack | Attack, usually in the form of an intrusive penetration test, directed at public-facing web servers, applications, and back-end databases.

Application programming interface (API) | Functions in a software application that are exposed to external programs to provide internal functionality on demand.

Application proxy firewall | An advanced firewall that processes all traffic between two systems. Instead of allowing a direct connection between two systems, the proxy connects to each system separately and passes filtered traffic to the destination based on filtering rules.

Application service provider (ASP) | A software company that builds applications hosted in the cloud and on the Internet and commercially sells that application in a one-to-many delivery model.

Approved scanning vendor (ASV) | A qualified and approved company able to perform Payment Card Industry (PCI) vulnerability assessment scans.

Arbitrary code execution | An exploit that allows a hacker to run unauthorized command line functions on a compromised system. Buffer overflow attacks and SQL injection attacks can often allow arbitrary code execution.

Armored virus | A virus that attempts to conceal itself from discovery, reverse engineering, or removal.

Asset | Any item that has value to an organization or a person.

Asymmetric key cryptography | A cryptographic technique that uses two mathematically related keys—one key to encrypt data and another key to decrypt data.

Asynchronous token | An authentication token used to process challenge-response authentication with a server. The token takes the server's challenge value and calculates a response. The user enters the response to authenticate a connection.

Attestation | The use of a trusted authority to confirm the authentication process. In effect, attestation relies on another party's ability to securely authenticate a subject.

Attestation of compliance (AOC) | Defined by the PCI DSS, this is an annual written statement of an organization's compliance signed by the chief executive officer, with any gaps or compensating

security controls identified and documented.

Attribute-based encryption (ABE) | A type of public key encryption in which the secret key of a user and the ciphertext are dependent on attributes of the sender, such as country or state.

Audit | An independent third-party review of an organization's existing financial situation, IT implementation, and/or IT security implementation. *See also security audit.*

Authentication | The process of proving someone is the person or entity he or she claims to be.

Authentication, authorization, and accounting (AAA) | Core services provided by one or more central servers to help standardize access control for network resources.

Authority-level policy | An authorization method in which access resources are decided by the user's authority level.

Authorization | The process of deciding who is approved for access to specific resources.

Authorizing official (AO) | A designated senior manager who reviews a certification report and decides whether to approve the system for implementation.

Availability | A mathematical formula that quantifies the amount of uptime compared to the amount of downtime for a system. Usually displayed as a ratio or percentage in a given calendar month.

B

Backdoor | An undocumented and often unauthorized access method to a computer resource that bypasses normal access controls.

Barricade | An object designed to obstruct movement from one place to another.

Baseline | A benchmark used to make sure that a system provides a minimum level of security across multiple applications and different products.

Bell–LaPadula model | An access control model that provides multilayered security for access to systems, applications, and data based on a hierarchy.

Benchmark | The standard by which a computer or device is compared to determine whether it is securely configured.

Biba integrity model | Access control rules designed to ensure data integrity. Data and subjects are grouped into ordered levels of integrity; this prevents users from corrupting data at a higher level than what the user may have access to and helps ensure data integrity.

Biometrics | A physiological or behavioral human-recognition system (e.g., fingerprint reader, retina scanner, or voice-recognition reader).

Birthday attack | A cryptographic attack on hash collisions (i.e., different text with same key), so named after the surprisingly high probability of any two classroom students (or any members in a group) sharing a birthday.

Black-box testing | A method of security testing that isn't based directly on knowledge of a program's architecture.

Black-hat hacker | A computer attacker who tries to break IT security for the challenge and to prove technical prowess.

Blacklisting | The act of maintaining a list of all known dangerous websites or destination IP addresses. Any messages from a site or this destination IP address in the blacklist is dropped.

Blanket purchase agreement (BPA) | An agreement that defines a streamlined method of purchasing supplies or services.

Block cipher | Cryptographic cipher that encrypts an entire block of input at a time.

Bluejacking | Sending unsolicited messages to another device using Bluetooth to get the recipient to open them and potentially infect the recipient device.

Bluesnarfing | Accessing a Bluetooth-enabled device with the intention of stealing data.

Border firewall | A firewall that separates a closed or secure network from external or public networks, such as the Internet.

Bot-herder | A hacker who operates a botnet.

Botnet | Robotically controlled network. A botnet consists of a network of compromised computers that attackers use to launch attacks and spread malware.

Brewer and Nash integrity model | Based on a mathematical theory published in 1989 to ensure fair competition.

Bring Your Own Device (BYOD) | An organizational policy of allowing or even encouraging employees, contractors, and others to connect their own personal equipment to the corporate network. This policy offers cost savings but requires proper security controls, policies, and procedures.

Browser add-on | Companion program that works with a web browser.

Brute-force password attack | A method used to attempt to compromise logon and password access controls by attempting every input combination. These attacks usually follow a specific attack plan, including the use of social engineering to obtain user information.

Buffer overflow | A condition in which a memory buffer exceeds its capacity and extends its contents into adjacent memory. Often used as an attack against poor programming techniques or poor software quality control. Hackers can inject more data into a memory buffer than it can hold, which may result in the additional data overflowing into the next area of memory. If the overflow extends to the next memory segment designated for code execution, a skilled attacker can insert arbitrary code that will execute with the same privileges as the current program. Improperly formatted overflow data may also result in a system crash.

Business associate | Under HIPAA, an organization that performs a health care activity on behalf of a covered entity where access to PHI or ePHI is required.

Business continuity plan (BCP) | A plan for how to handle outages to IT systems, applications, and data access in order to maintain business operations.

Business driver | Includes people, information, financials, and performance goals that support business objectives.

Business impact analysis (BIA) | A prerequisite analysis for a business continuity plan that prioritizes business operations and functions and their associated IT systems, applications, and data and the impact of an outage or downtime.

Business-to-business (B2B) | A term used to describe a business that builds online systems with links for conducting transactions with other businesses, usually for integrated supply chain purchases and deliveries.

Business-to-consumer (B2C) | A term used to describe an online storefront for consumers to purchase goods and services directly. An example of a B2C site is *www.amazon.com*.

C

Cache | An area of memory used to store frequently used data for quick retrieval.

Caesar cipher | A simple substitution cipher in which each letter is shifted three positions to the right, wrapping back around to *A* once the letter *Z* is reached.

California Consumer Privacy Act (CCPA) | A state law enacted in 2018 to protect consumer private data of California residents.

California Security Breach Information Act (SB 1386) of 2003 | A state act that requires any company that stores customer data electronically to notify its customers any time there is a security breach.

Carrier Sense Multiple Access/Collision Detection (CSMA/CD) | The IEEE 802.3 local area network (LAN) standard for access and collision detection on an Ethernet LAN segment.

Certificate authority (CA) | A trusted entity that stores and distributes verified digital certificates, such as Verisign or Computer Associates.

Certificate of completion | A document that verifies a student has completed courses and earned a sufficient score on an exam.

Certification | The technical evaluation of a system to provide assurance that the system has been implemented correctly. Also, an official statement that attests that a person has satisfied specific requirements. Requirements often include possessing a certain level of experience, completing a course of study, and passing an examination.

Certified Information Systems Security Professional (CISSP®) | A globally recognized information systems security professional certification offered by $(ISC)^2$.

Certifier | The individual or team responsible for performing the security test and evaluation (ST + E) for the system. The certifier also prepares the report for the authorizing officer on the risk of operating the system.

Chain of custody | The continuity of control of evidence that makes it possible to account for all that has happened to evidence between its original collection and appearance in court, preferably unaltered.

Challenge-Handshake Authentication Protocol (CHAP) | Decentralized authentication protocol that hashes passwords with a one-time challenge number to defeat eavesdropping and replay attacks.

Change control | The process of managing changes to computer/device configuration or application software.

Change control committee | A group that oversees all proposed changes to IT systems, applications, and production assets.

Characteristic | In authentication, a unique physical attribute or manner of expression, such as a fingerprint or a signature. Such attributes are often referred to as "something you are."

Checklist test | A simple review of the business continuity plan by managers and the business continuity team to make sure that contact numbers are current and that the plan reflects the company's priorities and structure.

Checksum | The output of a one-way algorithm. A mathematically derived numerical representation of some input.

Children's Internet Protection Act (CIPA) | A federal law enacted by Congress to address concerns about access to offensive content over the Internet on school and library computers where children and minors have access.

Children's Online Privacy Protection Act (COPPA) | Made effective in 2000, the COPPA Rule restricts how online information is collected from children under 13 years of age.

Chinese wall | A set of rules that makes sure no subject gets to objects on the other side of the "wall."

Christmas attack | *See Xmas attack.*

Cipher | An algorithm to encrypt or decrypt information.

Ciphertext | Encrypted data, the opposite of cleartext. Data sent as ciphertext is not intelligible or decipherable.

Clark and Wilson integrity model | Published in 1987 by David Clark and David Wilson, this model focuses on what happens when users allowed into a system try to do things they are not permitted to do.

Clean desk/clear screen policy | A policy stating that users must never leave sensitive information in plain view on an unattended desk or workstation.

Cleartext | Unencrypted data, or the opposite of ciphertext. Data sent as cleartext is readable and understandable.

Client-side attack | Attack relying on the user's workstation connecting with a malicious server or application.

Clipping level | A value used in security monitoring that tells the security operations personnel to ignore activity that falls below a stated value.

Cloud access security broker (CASB) | Software that provides integrated identity and access management services for cloud-based applications and storage.

Cloud computing | The practice of using computing services that are hosted in a virtualized data center with remote access to the application and data (e.g., Software as a Service [SaaS] utilizes cloud computing).

Cloud Security Alliance (CSA) | A nonprofit organization with a mission to promote security best practices for using cloud computing.

Cloud service provider (CSP) | A company that maintains data centers with racks of server computers, each running multiple virtual machines, and is able to provide services to many clients simultaneously. Organizations of all types turn to CSPs to avoid having to maintain their own data centers.

Clustering | A logical division of data composed of one or more sectors on a hard drive. A cluster is the smallest addressable unit of drive storage, usually 512; 1,024; 2,048; or 4,096 bytes, depending on the logical volume size.

Colluding | The action of multiple attackers planning a cyberattack; others working secretly, especially to do something illegal or unauthorized.

Collusion | Two or more people working together to violate a security policy.

Command injection | *See directory traversal.*

Common Criteria for Information Technology Security Evaluation | ISO/IEC 15408 standard for computer security.

Compensating control | A control that is designed to address a threat in place of one that is preferred but is too expensive or difficult to implement.

Compliance | The act of following laws, rules, and regulations that apply to an organization and its use of IT systems, applications, and data.

Compliance liaison | A person whose responsibility it is to ensure that employees are aware of and comply with an organization's security policies.

Confidentiality | The requirement to keep information private or secret.

Confidentiality, integrity, and availability (C-I-A) | The three main tenets of information security.

Configuration control | The process of managing the baseline settings of a system or device.

Connection encryption | Assurance that communication is secured from end to end, for example, between an HTTPS website and secure browser connection with a desktop or mobile device.

Consortium agreement | The legal definition for how members of a group will interact with one another.

Constrained user interface | Software that allows users to enter only specific information and perform only specific actions.

Content filtering | The blocking of specific keywords or phrases in domain-name and URL lookups. Specific URLs and domain names can be prevented from being accessed with web content filtering enabled.

Content inspection | Looking within an IP packet to determine whether the packet should be allowed to pass through the IP stateful firewall.

Continuing education | An educational program that is generally associated with a college or university that provides formal courses that do not lead to degree programs but do contribute to continuing education credits.

Continuing professional development (CPD) | A measurement of what one learns, trains, and applies in a professional work environment.

Continuing professional education (CPE) | A standard unit of credit that equals 50 minutes of instruction.

Continuous authentication | An authentication method in which a user is authenticated at multiple times or event intervals.

Control | *See security control.*

Control objective | The goal or final outcome of what a control or requirement must achieve when implemented correctly.

Cookie | A simple text file that contains details gleaned from past visits to a website. Cookies have value because HTTP is a stateless protocol (one that cannot retain data from one visit to the next), so a cookie file is used to keep a small record of the last visit.

Corrective control | A safeguard or countermeasure that mitigates or lessens the effect of the threat.

Countermeasure | An action taken to offset or address a specific threat.

Counter Mode Cipher Block Chaining Message Authentication Code Protocol (CCMP) | An encryption protocol that implements the 802.11i standard. CCMP provides enhanced security through the use of the Counter Mode of the AES standard.

Covered entity | Health plans, health care clearinghouses, and any health care provider that transmits certain types of health information in electronic form. These entities must follow the HIPAA Security and Privacy Rules.

Covert act | An act carried out in secrecy.

Covert channels | Hidden ways of passing information against organizational policy.

Cracker | A computer attacker who has hostile intent, possesses sophisticated skills, and may be interested in financial gain.

Credential harvesting | Using stolen user IDs and passwords to gain unauthorized access to systems and applications. Also known as credential stuffing.

Credential management | A system for collecting, managing, and using the information associated with access controls, such as login IDs and passwords.

Critical business function (CBF) | A business function or process that must be operational for an organization to carry out its core business operations.

Crossover error rate | The point where a biometric device's sensitivity returns false rejections and false acceptance equally.

Cross-platform virus | Virus that is harmful on more than one platform or operating system, such as a virus effective on both Linux and Windows.

Cross-site request forgery (XSRF) | Similar to the XSS attack, an attacker provides script code that causes a trusted user who views the input script to send malicious commands to a web server. The XSRF attack exploits the trust a server has in a user.

Cross-site scripting (XSS) | An attack in which an attacker inputs client-side script code to a web application. The code is then viewed by other users, and their client software executes the script instructions. The XSS attack exploits the trust users have for a server. The results of an XSS attack can include the corruption of the data on the website or identity theft of the site's visitors.

Cryptanalysis | The process of breaking codes without knowledge of the key.

Cryptogram | A small encrypted message.

Cryptographic hash | An algorithm that converts a large amount of data to a single number.

Cryptography | The study or practice of hiding information.

Cryptolocker | A specific form of ransomware that encrypts critical files or data until the victim pays a ransom to obtain the decryption keys.

Cryptosystem | The algorithms or ciphers used to encrypt and decrypt data.

Cybersecurity | The act of securing and protecting individuals, businesses, organizations, and governments that are connected to the Internet and the web.

Cyberspace | The global online virtual world created by the Internet where individuals, businesses, organizations, and governments connect to one another.

D

Data breach | An incident in which sensitive data is accessed and stolen.

Data classification standard | A definition of different data types with respect to security sensitivity.

Data Encryption Standard (DES) | Product encryption cipher with a 56-bit key consisting of 16 iterations of substitution and transformation. First published as a Federal Information Processing Standard (FIPS) in 1977.

Datagram | The collective name for the IP packet including the header and the payload or data.

Data infector | A type of virus that attacks document files containing embedded macro programming capabilities.

Data recovery | The process of extracting data that has been deleted or exists on damaged media.

Decentralized access control | A system that puts access control into the hands of people, such as department managers, who are closest to system users; there is no one centralized entity to process access requests in this system.

Decryption | The act of unscrambling ciphertext into plaintext.

Defense in depth | The implementation of multiple layers of security (defense) throughout the IT infrastructure (depth). Also called the castle approach.

Degausser | A device that creates a magnetic field that erases data from magnetic storage media.

De-identified data | Information about an individual that contains nothing that could be linked to a specific individual's identity (e.g., name, address, or date of birth).

Delphi method | An information and opinion collection method that employs formal anonymous surveys in multiple rounds.

Demilitarized zone (DMZ) | An exterior network that acts as a buffer zone between the public Internet and an organization's IT infrastructure (i.e., LAN-to-WAN Domain).

Denial of service (DoS) attack | An attack that uses ping or ICMP echo-request, echo-reply messages to bring down the availability of a server or system. DoS attacks are usually sourced from a single-host device.

Detective control | A control that detects when an action has occurred. It includes smoke detectors, log monitors, and system audits.

Deterrent control | A control that warns the user that completing a requested action could result in a violation or threat.

DIAMETER | A popular centralized access control protocol that succeeded RADIUS and provides access control for stable and static workforces.

Dictionary password attack | An attack method that takes all the words from a dictionary file and attempts to log on by entering each dictionary entry as a password.

Differential cryptanalysis | The act of looking for patterns in vast amounts of ciphertext.

Diffie–Hellman algorithm | An algorithm in which a sender and a receiver use asymmetric encryption to securely exchange symmetric keys.

Diffie–Hellman in ephemeral mode (DHE) | Asymmetric cryptographic key exchange algorithm that uses modular arithmetic to generate keys.

Digital forensics | The practice of applying forensic science to investigations of IT incidents.

Digital signature | An object that uses asymmetric encryption to bind a message or data to a specific entity.

Digital Signature Algorithm (DSA) | The NIST standard for digital signatures. First published as a Federal Information Processing Standard (FIPS) in 1993.

Digitized signature | An image of an electronically reproduced signature.

Directory information | Information that is publicly available about users of a computer system, such as all students at a school.

Directory traversal | The act of accessing a file directory outside a web server's root directory and, where possible, including a command to execute from an unauthorized directory.

Disaster recovery plan (DRP) | A written plan for how to handle major disasters or outages and recover mission-critical systems, applications, and data.

Disclosure | (1) Any instance of an unauthorized user accessing protected information. (2) A reference, under HIPAA, to how a covered entity shares protected information with other organizations.

Discretionary access control (DAC) | A means of restricting access to objects based on the identity of subjects and/or groups to which they belong.

Disruption | A sudden unplanned event.

Distributed denial of service (DDoS) | An attack that uses ping or ICMP echo-request, echo-replay messages to bring down the availability of a server or system. DDoS attacks initiate from more than one host device.

DNS poisoning | A form of exploitation in which the data on a Domain Name System server is falsified so subsequent responses to DNS resolution queries are incorrect. DNS poisoning can wage man-in-the-middle attacks.

Domain Name System (DNS) | A network service that resolves fully qualified domain names (FQDNs) into their corresponding IP address. DNS is an essential service of most networks and their directory services.

Downtime | The amount of time that an IT system, application, or data is not available to users.

Dumpster diving | A type of reconnaissance in which an attacker examines an organization's trash or other discarded items to learn internal or private information. The results of dumpster diving are often used to wage social engineering attacks.

Dynamic Host Configuration Protocol (DHCP) | A protocol used on IP networks to automatically provide configuration details to client computers.

E

Eavesdropping | (1) The act of listening in on a conversation. (2) The capture and monitoring of network IP packets using a packet sniffer.

E-commerce | The buying and selling of goods and services online through a secure website, with payment by credit card or direct debit from a checking account.

E-discovery | Short for electronic discovery, the general process of engaging in investigative activities to find and recover digital data for evidence.

Electronic protected health information (ePHI) | Patient health information that is computer based. It is PHI stored electronically.

Electrotechnology | The collective body of knowledge addressed by the International Electrotechnical Commission (IEC).

Elliptic curve cryptography (ECC) | A public key cryptographic algorithm based on the structure of elliptic curves.

Elliptic Curve DHE (ECDHE) | An asymmetric cryptographic key exchange algorithm that uses algebraic curves to generate keys.

Emergency operations center (EOC) | The place in which the recovery team meets and works during a disaster.

Emergency operations group | A group that is responsible for protecting sensitive data in the event of a natural disaster or equipment failure, among other potential emergencies.

EMI shielding | The practice of using magnetic or conductive material to reduce the effect of outside electromagnetic interference (EMI) on sensitive electronic equipment.

Encryption | The act of transforming cleartext data into undecipherable ciphertext.

End of Life (EOL) | A term used to describe the date by which the vendor or manufacturer ceases to support and provide software updates and patches for a product or software application. Also referred to as End of Service Life (EOSL).

End-User License Agreement (EULA) | A licensing agreement between the software manufacturer and users that limits the liability for software errors, bugs, or vulnerabilities.

Ethernet | An IEEE 802.3 CSMA/CD standard for wired networking supporting speeds from 10 Mbps to over 10 Gbps.

Ethical hacker | An information security or network professional who uses various penetration test tools to uncover or fix vulnerabilities. Also called a white-hat hacker.

European Telecommunications Standards Institute (ETSI) | A European standards organization that develops standards for information and communications technologies (ICT) that are commonly adopted by member countries in the European Union (EU).

Event | Any observable occurrence within a computer or network.

Event-based synchronization system | An authentication method in which a token's value is synchronized with a server based on each access request. The token's counter is increased each time a new value is requested.

Event log | A software- or application-generated record that some action has occurred.

Evidence | Anything presented to support an assertion.

Evil twin | A form of wireless network attack in which an attacker creates a bogus open or public wireless network in order to sniff and capture all IP packets when a user connects to it.

Exploit | The act of realizing a threat against a vulnerability.

Exploit software | An application incorporating known software vulnerabilities, data, and scripted commands to exploit a weakness in a computer system or IP host device.

Extensible Authentication Protocol (EAP) | An authentication framework that defines the transport of keys and authentication credentials. EAP is commonly used in wireless network authentication.

F

False negative | Incorrectly identifying abnormal activity as normal.

False positive | Incorrectly identifying normal activity as abnormal.

Familiarity | A type of social engineering attack that relies on constant and frequent interaction with individuals to create a comfort with (or familiarity and liking for) an individual to extract information.

Family Educational Rights and Privacy Act (FERPA) | A U.S. federal law that protects the private data of students, including their transcripts and grades, with which K–12 and higher education institutions must comply.

Fault tolerance | The ability to encounter a fault, or error, of some type and still support critical operations.

Federal Financial Institutions Examination Council (FFIEC) | An interagency body of five U.S. regulatory agencies that exist to promote uniformity and consistency in the supervision of financial institutions. *See www.ffiec.gov/.*

Federal Information Security Management Act of 2002 (FISMA) | A U.S. federal law that requires U.S. government agencies to protect citizens' private data and have proper security controls in place.

Federal Information Security Modernization Act of 2014 (FISMA) | A U.S. federal law enacted to bring the requirements of the Federal Information Security Management Act 2002 up to date with modern threats and security practices.

Federation | A collection of servers that share authentication credentials.

Fibre Channel | A storage networking protocol originally used in supercomputers to connect storage devices.

Fibre Channel over Ethernet (FCoE) | A protocol used to connect Fibre Channel–capable devices to an Ethernet network.

FICO | A publicly traded company that provides information used by the consumer credit reporting agencies Equifax, Experian, and TransUnion.

File infector | A type of virus that primarily infects executable programs.

File Transfer Protocol (FTP) | A nonsecure file transfer application that uses connection-oriented TCP transmissions with acknowledgments.

Firewall | A program or dedicated hardware device that inspects network traffic passing through it and denies or permits that traffic based on a set of rules that are determined at configuration.

Firewall rules | Filters defined in a firewall's configuration that enable the security professional to implement security requirements.

Flash cookies | A type of web application attack that uses Flash to plant cookie-like objects on users' systems even when they think they have cleared their computers of such objects. Less commonly called a local shared object (LSO).

Flood guard | Firewall rules that can limit traffic bandwidth from hosts, reducing the ability for any one host to flood a network.

Forensics | Techniques based on science used to collect, analyze, and describe evidence in a manner that is acceptable by a court of law.

Functional policy | A statement of an organization's management direction for security in such specific functional areas as email, remote access, and Internet surfing.

Fuzzing | A software testing method that consists of providing random input to software to see how it handles unexpected data.

G

Gap analysis | A comparison of security controls in place and the controls that are needed to address all identified threats.

General Data Protection Regulation (GDPR) | A regulation in European Union (EU) law that protects each EU citizen's individual data.

Government Information Security Reform Act (Security Reform Act) | The precursor to the Federal Information Security Management Act (FISMA); required U.S. government agencies to have an information security program and to perform periodic risk assessments and made security awareness training mandatory for U.S. government employees.

Gramm-Leach-Bliley Act (GLBA) | A U.S. federal law requiring banking and financial institutions to protect customers' private data and have proper security controls in place.

Gray-box testing | Security testing that is based on limited knowledge of an application's design.

Gray-hat hacker | A computer attacker with average abilities who may one day become a black-hat hacker. Also called wannabe.

Group membership policy | An authorization method in which access to resources is decided by what group(s) you are in.

Group Policy | A centralized set of rules that govern the way Windows operates.

Group Policy Object (GPO) | A named object that contains a collection of Group Policy settings.

Guideline | A recommendation for how to use or purchase a product or system.

H

Hacker | A computer expert who explores computing environments to gain knowledge.

Hacktivist | A hacker who is or claims to be motivated by political or social justice concerns and uses hacking skills to reinforce his or her chosen position.

Hardened configuration | The state of a computer or device in which you have turned off or disabled unnecessary services and protected the ones that are still running.

Hardening | A process of changing hardware and software configurations to make computers and devices as secure as possible.

Hash | An algorithm that converts a large amount of data to a single (long) number. Once mathematically hashed, the hash value can be used to verify the integrity of that data.

Hash function | A one-way function that takes input and produces output that is hard to replicate and extremely difficult to reverse.

Header manipulation | The act of stealing cookies and browser URL information and manipulating the header with invalid or false commands to create an insecure communication or action.

Health Insurance Portability and Accountability Act (HIPAA) | A U.S. federal law requiring health care institutions and insurance providers to protect patients' private data and have proper security controls in place.

Hijacking | A type of attack in which the attacker takes control of a session between two machines and masquerades as one of them.

HMAC-based one-time password (HOTP) | An algorithm that provides a very secure method to authenticate a mobile device user using an authentication server.

Hoax | An act intended to deceive or trick the receiver. In this context, hoaxes normally travel in email messages. Often, these messages contain warnings about devastating new viruses.

Honeynet | A group of honeypots made to simulate a real live network, but isolated from it.

Honeypot | A host or service deployed at the edge of a network to act as bait for potential hacking attacks. The purpose of the honeypot is to provide a controlled environment for attacks, which enables the easy detection and analysis of the attack to test the strength of the network.

Hub | A legacy network device that connects network segments, echoing all received traffic to all other ports.

Hypertext Transfer Protocol (HTTP) | An application layer protocol that allows users to communicate and access content via webpages and browsers.

Hypertext Transfer Protocol Secure (HTTPS) | The combination of HTTP and SSL/TLS encryption to provide security for data entry by users entering information on secure webpages, such as those found on online banking websites.

I

ICMP echo request | An IP communication mechanism that sends a ping request and expects a ping reply.

Identification | The process of providing credentials to claim to be a specific person or entity.

Identity and access management (IAM) | Software services that enable organizations to outsource the tasks of credential management using external application programming interface (API) calls.

Identity-based encryption (IBE) | Uses the sender's identity to derive a key.

Identity theft | The act of stealing personally identifiable information with the intent to open new accounts, make purchases, or commit fraud.

Impact | The magnitude of harm that could be caused by a threat exercising a vulnerability.

Impersonation | From a website or web application perspective, an attacker's attempt to use the session credentials of a valid user.

Implicit deny | Firewall configuration that will deny all messages, except the ones that you explicitly allow.

In-band key exchange | The use of one's own IP data network to exchange keys.

Incident | An event that results in violating a security policy or poses an imminent threat to a security policy.

Incident response team (IRT) | Members of the organization who have the training and documentation necessary to respond to incidents as they occur. The team members include an incident team leader, communications team leader, and IT and IT security personnel.

Information security | The protection of data itself.

Information systems | The servers and application software on which information and data reside.

Information systems security | The protection of computing systems, applications, and data.

Inherent risk | Risk as it currently exists, with any current controls in place.

Initiative for Open Authentication (OATH) | A collaborative organization supporting open standards and use of encryption for authentication.

Injection technique | A technique used to carry out attacks by deliberately inputting invalid data to disrupt or circumvent software controls.

Insider threat | The danger originating from an employee, contractor, or person trusted within the organization.

Institute of Electrical and Electronics Engineers (IEEE) | A standards body that defines specifications and standards for electronic technology.

Integer overflow | The act of creating a mathematical overflow that exceeds the maximum size allowed. This overflow can cause a financial or mathematical application to freeze or create a vulnerability and attack opening.

Integrity | The validity of information or data. Data with high integrity has not been altered or modified.

Intellectual property | The unique knowledge a business possesses that gives it a competitive advantage over similar companies in similar industries.

Interconnection security agreement (ISA) | An interoperability agreement, often an extension of an MOU, that documents technical requirements of interconnected assets.

International Electrotechnical Commission (IEC) | The predominant organization for developing and publishing international standards for technologies related to electrical and electronic devices and processes.

International Information Systems Security Certification Consortium | *See (ISC)^2*.

International Organization for Standardization (ISO) | An international nongovernmental organization with the goal of developing and publishing international standards.

International Telecommunication Union (ITU) | The main United Nations agency responsible for managing and promoting information and technology issues.

Internet | A global network of computer networks that uses the TCP/IP family of protocols and applications to connect nearly 2 billion users.

Internet Architecture Board (IAB) | A subcommittee of the IETF composed of independent researchers and professionals who have a technical interest in the overall well-being of the Internet.

Internet Control Message Protocol (ICMP) | A management protocol for IP networks.

Internet Engineering Task Force (IETF) | A standards organization that develops and promotes Internet standards.

Internet of Things (IoT) | A term used to refer to the large number of networked devices (e.g., personal items, home appliances, cloud services, and vehicles) that can now connect to the Internet.

Internet Protocol Security (IPSec) | A suite of protocols designed to connect sites securely using IP networks.

Internet Small Computer System Interface (iSCSI) | A storage networking protocol used to link data storage devices to IP networks.

Interoperability | A term used to describe computers, devices, or applications that can be configured to work together.

Intrusion detection system/intrusion prevention system (IDS/IPS) | Network security appliances typically installed within the LAN-to-WAN Domain at the Internet ingress/egress point to monitor and block unwanted IP traffic.

Intrusive penetration testing | The testing that a hacker performs to break into a computer system or IP host device; intrusive testing generates malicious network traffic.

IP address | A 32-bit (IPv4) or 128-bit (IPv6) number that uniquely identifies a device, such as a computer, on a network.

IP default gateway router | The router interface's IP address that acts as a LAN's ingress/egress device.

IP stateful firewall | A device that examines the IP, TCP, and UDP layers within a packet to make blocking or forwarding decisions. Firewalls are placed at the ingress/egress points where networks interconnect.

IPv4 address | A 4-byte (32-bit) address that uniquely identifies a device on a network.

IPv6 address | A 16-byte (128-bit) address that uniquely identifies a device on a network.

(ISC)^{2}© | International Information Systems Security Certification Consortium. A nonprofit organization dedicated to certifying information systems security professionals.

ISO 17799 | An international security standard that documents a comprehensive set of controls that represent information system best practices.

ISO/IEC 27002 | An update to the ISO 17799 standard.

IT security policy framework | A set of rules for security. The framework is hierarchical and includes policies, standards, procedures, and guidelines.

ITU Telecommunication Sector (ITU-T) | The committee of the ITU responsible for ensuring the efficient and effective production of standards covering all fields of telecommunications for all nations.

IV attack | A wireless network attack that modifies the initialization vector of an encrypted IP packet in transmission in hopes of being able to decrypt a common encryption key over time.

J

Jamming | The act of sending radio frequencies in the same frequency as wireless network access points to jam and interfere with legitimate wireless communications.

Job rotation | A strategy to minimize risk by rotating employees between various systems or duties.

Job task analysis | The survey of how job tasks and responsibilities align with a particular role.

K

Key | A secret value a cipher uses to encrypt or decrypt information.

Key directory | A trusted repository of all public keys.

Key distribution | The process of securely transporting an encryption key from the key generator to the key user, without disclosing the key to any unauthorized user.

Key distribution center (KDC) | The process of issuing keys to valid users of a cryptosystem so they can communicate.

Key escrow | An external key storage method that allows an authorized third party access to a key under certain circumstances.

Key management | The process of managing and maintaining encryption keys.

Key revocation | A situation in which a person is no longer trusted or allowed to use a cryptosystem. In a symmetric key system, where everyone shares the same key, compromising one copy of the key comprises all copies.

Key stretching | A function that takes a key (generally a weak key) as input and generates an enhanced key that can withstand a more determined attack.

Key-encrypting key | An encryption key used to encrypt other keys before transmitting them.

Keyspace | The set of all possible encryption keys.

Keystroke logger | Surveillance software or hardware that records to a log file every keystroke a user logs. Also known as a keylogger.

Keyword mixed alphabet cipher | An encryption cipher that uses a cipher alphabet that consists of a keyword, less duplicates, followed by the remaining letters of the alphabet.

Knowledge | In authentication, this is something a person knows, such as a password, a passphrase, or a PIN.

L

Layer 2 switch | A network switch that examines the MAC layer address of an IP packet to determine where to send it. It supports LAN connectivity, typically via unshielded twisted-pair cabling at 10/100/1,000 or 10 Gbps Ethernet speeds.

Layer 3 switch | A network switch that examines the network layer address of an Ethernet frame to determine where to route it. It supports LAN connectivity, typically via unshielded twisted-pair cabling at 10/100/1,000 or 10 Gbps Ethernet speeds and is the same thing as a router.

LDAP injection | An attack that exploits websites that constructs LDAP based on user input. Web applications that don't sanitize input enable attackers to alter how LDAP statements are constructed. LDAP statements that are modified by an attacker run with the same permissions as the component that executed the command so a fake or bogus ID and authentication LDAP commands and packets can be sent to a web application to authenticate.

Least privilege | The principle in which a subject (i.e., a user, an application, or another entity) should be given the minimum level of rights necessary to perform legitimate functions.

Legal hold | A process that requires an organization to preserve and not alter evidence that may be used in court.

Lightweight Directory Access Protocol (LDAP) | A directory service for network-based authentication. LDAP communication can be encrypted.

Lightweight Extensible Authentication Protocol (LEAP) | Wireless authentication framework developed by Cisco systems to help manage wireless keys and authentication. LEAP could use either WEP or TKIP for setting up secure connections.

Likelihood | The probability that a potential vulnerability might be exercised within the construct of an associated threat environment.

Load balancer | A network device (often a firewall) that can dynamically route network traffic to different network segments to avoid congestion.

Load balancing | (1) Routing protocols that divide message traffic over two or more links. (2) Using two or more servers to respond to service requests.

Local area network (LAN) | A collection of computers that are connected to one another or to a common medium. Computers on this type of network are generally within an area no larger than a building.

Local shared objects (LSO) | *See Flash cookies.*

Log analysis | The process of reviewing firewall and other network device log files to identify reconnaissance activity or even attacks that have already occurred.

Log file | Journaled entries that provide information, such as who logged on to the system, when they logged on, and what information or resources were accessed.

Logic bomb | A piece of code designed to cause harm that is intentionally inserted into a software system to be activated by some predetermined trigger.

Logical access control | A mechanism that limits access to computer systems and network resources.

Loop protection | Firewall rules configured to look at message addresses and deny any messages sent around an unending loop.

Loss expectancy | The amount of money that is lost as a result of an IT asset failure.

M

MAC address filter | Firewall filtering rules that filter wireless network traffic by the MAC address.

Macro virus | A type of virus that typically infects a data file and injects malicious macro commands.

Malicious add-on | Software plug-in or add-on that runs additional malicious software on legitimate programs or software applications.

Malicious attack | An attempt to exploit a vulnerability on an IT hardware asset or application.

Malicious code | Software written with malicious intent, for example, a computer virus.

Malicious software | Software designed to infiltrate one or more target computers and follow an attacker's instructions. Also called malware.

Malware | *See malicious software.*

Malware inspection | A specialized form of content inspection that looks at packet content for signs of malware.

Management control | A control that is designed to manage the risk process.

Mandatory access control (MAC) | A means of restricting access to an object based on the object's classification and the user's security clearance.

Mandatory vacation | Compulsory time during which workers must step away from their work responsibilities, often used as a time to audit critical functions.

Man-in-the-middle attack | An attack in which the attacker gets between two parties and intercepts messages before transferring them on to their intended destination.

Mantrap | A physical security safeguard that controls entry into a protected area. This entry method has two sets of doors on either end of a small room.

Masking | The use of a special character (e.g., X or *) to hide some of the characters of a sensitive data element, such as a credit card number or a Social Security number.

Masquerade attack | An attack in which one user or computer pretends to be another user or computer.

Maximum tolerable downtime (MTD) | The amount of time that critical business processes and resources can be offline before an organization begins to experience irreparable business harm.

Mean time between failures (MTBF) | The predicted amount of time between failures of an IT system during production operation.

Mean time to failure (MTTF) | The average amount of time a device is expected to operate before encountering a failure.

Mean time to repair (MTTR) | The average amount of time required to repair a device.

Memorandum of understanding (MOU) | An agreement between two or more parties that expresses areas of common interests that result in shared actions.

Metadata | A term used to refer to data about data (e.g., there are 100 entries in the database table; of the 100 entries, 99 were inputted manually and 1 was inputted automatically).

Miller test | The three-prong approach defined by the U.S. Supreme Court to decide whether to label something as obscene.

Minimum necessary rule | A rule that covered entities may disclose only the amount of protected health information absolutely necessary to carry out a particular function.

Mitigation activities | Any activities designed to reduce the severity of a vulnerability or remove it altogether.

Mobile device management (MDM) | The practice of security management for employees' mobile devices.

Mobile IP | A protocol for allowing mobile devices to transparently switch LAN segments.

Mobility | The ability to perform job functions without having to be physically confined to one office or location.

Multifactor authentication (MFA) | Using two or more types of authentication credentials to authenticate an identity.

Multiprotocol Label Switching (MPLS) | A wide area network (WAN) technology that operates at Layer 2 by inserting labels or tags in the packet header for creating virtual paths between endpoints in a WAN infrastructure. This is a faster method of transporting IP packets through the WAN without requiring routing and switching of IP packets.

Multipartite virus | A type of virus that infects other files and spreads in multiple ways.

Multitenancy | A database feature that allows different groups of users to access the database without being able to access each other's data.

Mutual aid | An agreement between organizations able to help each other by relocating IT processing in a time of need from a disaster.

N

National Centers of Academic Excellence in Information Assurance Education (CAE/IAE) | Educational institutions that meet specific federal information assurance educational guidelines.

National Centers of Academic Excellence in Research (CAE/R) | Institutions that meet specific federal information assurance research guidelines.

National Institute of Standards and Technology (NIST) | A federal agency within the U.S. Department of Commerce whose mission is to "promote U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology in ways that enhance economic security and improve our quality of life."

National Vulnerability Database (NVD) | A publicly accessible database of known security vulnerabilities, formerly known as the Common Vulnerability and Exposures list.

Near field communication attack | The act of intercepting at close range (a few inches) communications between two mobile operating system devices.

Need to know | A property that indicates a specific subject needs access to a specific object. This is necessary to access the object in addition to possessing the proper clearance for the object's classification.

Network access control (NAC) | A method to restrict access to a network based on identity or other rules.

Network address translation (NAT) | A method of IP address assignment that uses an alternate, public IP address to hide a system's actual, internal IP address.

Network interface controller (NIC) | The physical interface between a computer and the Ethernet LAN. It contains a unique 6-byte MAC-layer address.

Network key | Software encryption key used for encrypting and decrypting network traffic.

Network mapping | Using tools to determine the layout and services running on an organization's systems and networks.

Network operations center (NOC) | The command control center for a telecommunication service provider's backbone network and customer networks. Customer trouble calls are answered by the NOC in support of managed services and SLAs.

Network port | A hardware jack on a networking device into which a network cable is plugged, or a software construct that identifies a certain type (or class) of network messages destined for a specific type of network service.

Network reconnaissance | Gathering information about a network or system for use in a future attack.

Network segmentation | Firewall filtering rules that enforce divisions between networks, keeping traffic from moving from one network to another.

Nonpublic personal information (NPI) | Any personally identifiable financial information that a consumer provides to a financial institution. This term is defined by the Gramm-Leach-Bliley Act.

Nonrepudiation | The guarantee that every action is associated with a unique identity, preventing an identified party from denying that party carried out an action.

O

Offboarding | A process when terminating interoperability relationships that defines how to transfer control of data and other assets, terminate communications, and complete any open transactions.

Onboarding | A process when setting up interoperability relationships that provides the opportunity to clearly communicate goals and expectations for all parties.

One-time pad cipher | *See Vernam cipher.*

One-way algorithm | An encryption algorithm that has no corresponding decryption algorithm.

Open cipher | A cipher for which source code is readily available, which makes it possible for experts around the world to examine the cipher for weaknesses.

Open Systems Interconnection (OSI) Reference Model | An internationally accepted framework of standards that govern how separate computer systems communicate using networks.

Operating system fingerprinting | A reconnaissance technique that enables an attacker to use port mapping to learn which operating system and version is running on a computer.

Operating system (OS) fingerprint scanner | A software program designed to distinguish OSs based on small variations in TCP/UDP packet replies.

Operational control | A control that operational personnel may implement and manage, such as physical security and incident response.

Opportunity cost | The amount of money a company loses due to either intentional or unintentional downtime.

Order of volatility | A list of locations of data, from the most volatile to the least volatile, to help investigators collect the most volatile evidence first.

Out-of-band key exchange | A communication channel through which keys can be exchanged that is different from the one used for data.

Overt act | An act carried out in the open or easily viewed by others.

Overwriting | The process of repetitively writing data to specific areas on a physical storage media to effectively replace any previous data stored in those areas.

Ownership | In authentication, this is something a person has, such as a smart card, key, badge, or token.

P

Packet-filtering firewall | A firewall that examines each packet it receives and compares that packet to a list of rules configured by the network administrator.

Packet sniffer | A software application that uses a hardware adapter card in promiscuous mode to capture all network packets sent across a network segment.

Pagefile | A file that an operating system uses to temporarily store parts of main memory to facilitate multiple programs running at the same time.

Parallel test | The same as a full-interruption test, except that processing does not stop at the primary site.

Passphrase | An authentication credential that is generally longer and more complex than a password. Passphrases can also contain multiple words.

Password Authentication Protocol (PAP) | Decentralized authentication protocol that uses cleartext usernames and passwords.

Password cracker | A software program that performs one of two functions: brute-force password attack to gain unauthorized access to a system or recovery of passwords stored in a computer system.

Patch | A piece of software or code that fixes a program's security vulnerabilities. Patches are available for many types of software, including operating systems.

Pattern- or signature-based IDS | An intrusion detection system that uses pattern and stateful matching to compare current traffic with activity patterns (signatures) of known network intruders.

Payment Card Industry Data Security Standard (PCI DSS) | A standard, not a compliance law, for merchants and service providers regarding safeguarding the processing, storage, and transmission of cardholder data.

Penetration testing | A testing method that tries to exploit a weakness in the system to prove that an attacker could successfully penetrate it.

Perfect forward secrecy | An approach in which each communication session setup process is unique. Even if an attacker compromises a current session's keys, none of the previous sessions' keys are at risk.

Personally identifiable information (PII) | Data that can be used to individually identify a person. Examples include Social Security numbers, driver's license numbers, financial account data, and health data.

Pharming | An attack that seeks to obtain personal or private financial information through domain spoofing.

Phishing | A type of fraud in which an attacker attempts to trick the victim into providing private information.

Phreaking | The art of exploiting bugs and weaknesses that exist in the telephone system.

Physical access control | A mechanism that regulates access to physical resources, such as buildings or rooms.

Physically constrained user interface | A user interface that does not provide a physical means of entering unauthorized information.

Plaintext | Unencrypted information.

Point-to-Point Tunneling Protocol (PPTP) | A protocol to implement a VPN connection between two computers.

Polymorphic virus | A type of malware that includes a separate encryption engine that stores the virus body in encrypted format while duplicating the main body of the virus.

Port scanner | A tool used to scan IP host devices for open ports that have been enabled.

Port security | Firewall filtering rules that filter traffic based on ports.

Post–quantum cryptography | Techniques that mainly use asymmetric cryptography of sufficient strength to withstand attacks by quantum computers.

Preservation | Ensuring that evidence remains in the same state as when it was collected.

Preventive control | A control that stops an action before it occurs. It includes locked doors, firewall rules, and user passwords.

Privacy | The protection of individual rights to nondisclosure.

Privacy policy | A policy that specifies how an organization collects, uses, and disposes of information about individuals.

Private (symmetric) key | Encryption cipher that uses the same key to encrypt and decrypt information.

Privately held company | A company held by a small group of private investors.

Proactive change management | The act of initiating changes to avoid expected problems.

Procedure | A set of step-by-step actions to be performed to accomplish a security requirement, process, or objective.

Product cipher | Encryption cipher that is a combination of multiple ciphers, either transposition or substitution.

Project Management Body of Knowledge (PMBOK) | A collection of the knowledge and best practices of the project management profession.

Project Management Institute (PMI) | A nonprofit international organization of project managers that promotes the field of project management.

Promiscuous mode | The mode in which sniffers operate; it is nonintrusive and does not generate network traffic. This means that every data packet is captured and can be seen by the sniffer.

Protected Extensible Authentication Protocol (PEAP) | An authentication framework running in a TLS tunnel. PEAP provides more security than EAP for authentication exchanges.

Protected health information (PHI) | Any individually identifiable information about the past, present, or future health of a person. It includes mental and physical health data.

Protocol | A list of rules and methods for communicating.

Protocol analyzer | A software program that enables a computer to monitor and capture network traffic, including passwords and data in cleartext.

Provenance | The point of origin of a piece of evidence.

Proximity reader | A device that can sense a person's nearby token or access card without requiring physical contact.

Proxy firewall | A network device or computer that serves as a firewall and an intermediary between internal computers and computers on the Internet.

Proxy server | A server that is placed on a DMZ LAN and acts as a middleman for data sharing between the outside world and a user. It assumes risks, threats, and vulnerabilities so that the workstations it is connected to do not have to.

Public (asymmetric) key | An encryption key that can be shared and does not need to be kept private.

Public key cryptography | Cryptographic algorithm that uses two mathematically related keys—one key to encrypt and another key to decrypt data.

Public key infrastructure (PKI) | A general approach to handling encryption keys using trusted entities and digital certificates; the hardware, software, policies, and procedures to manage all aspects of digital certificates.

Publicly traded company | A company owned by several investors, who own shares of their stock.

Q

Qualified security assessor (QSA) | A certified individual qualified and authorized to perform PCI compliance assessment.

Qualitative risk assessment | A type of risk assessment that describes risks and then ranks their relative potential impact on business operations.

Quantitative risk assessment | A type of risk assessment that assigns a numerical value, generally a cost value, to each risk, making risk impact comparisons more objective.

Quantum cryptography | Cryptography algorithms that are based on physics concepts as opposed to traditional cryptographic algorithms based on mathematics.

R

Radio frequency identification (RFID) | A technology that exchanges data through a wireless connection between a reader and a tag attached to a product to track the movement of the product.

Rainbow tables | Type of password cracker that works with precalculated hashes of all passwords available within a certain character space.

Ransomware | Malicious computer software that takes over a system, encrypting files with a secret key that renders them inaccessible to legitimate users until they pay a ransom.

Reactive change management | The act of enacting changes in response to reported problems.

Real-time communications | A communication method in which messages are sent directly to the recipient immediately (in real time).

Real-time monitoring | Analysis of activity as it is happening.

Reciprocal center | Data center of businesses that do the same type of work but are not direct competitors and can be used as an alternate processing site in case of a disaster.

Recommendations | Formal term for ITU-T international standards.

Reconnaissance | The process of gathering information.

Recovery point objective (RPO) | The maximum acceptable level of data loss after a disaster.

Recovery time objective (RTO) | A defined metric for how long it must take to recover an IT system, application, and data access.

Redundancy | The feature of network design that ensures the existence of multiple pathways of communication whose purpose is to prevent or avoid single points of failure.

Redundant Array of Inexpensive Disks (RAID) | A disk set management technology that gains speed and fault tolerance. RAID can provide some protection against hard drive failure but does not protect against software or data compromises, such as virus infection.

Reference architecture | A template that defines the general layout of a process.

Reference monitor | Software that provides a central point of processing for all resource access requests.

Relationship | Optional condition that exists between users and resources. It is permissions granted to an authorized user, such as read, write, and execute.

Remediation | The act of fixing a known risk, threat, or vulnerability that is identified or found in an IT infrastructure.

Remote Authentication Dial-In User Service (RADIUS) | Popular protocol, first introduced in the early 1990s, that supports remote user authentication for large numbers of users wishing to connect to central servers.

Remote code execution | *See arbitrary code execution.*

Remote journaling | Method of recording transactions to a remote server in real time.

Remote wiping | The ability to remotely wipe or delete data on a device or storage media.

Removable storage | Storage media that can be removed and/or replaced with relative ease and without damage.

Replay attack | A type of attack in which a hacker uses a network sniffer to capture network traffic and then retransmits that traffic back on to the network at a later time. These attacks often focus on authentication traffic in the hope that retransmitting the same packets that allowed the real user to logon to a system will grant the hacker the same access.

Report of compliance (ROC) | Defined by the PCI DSS, this is a summary of the assessment activities performed during an audit. It is included as part of the attestation of compliance.

Request for comments (RFC) | A document produced by the IETF, RFCs contain standards as well as other specifications or descriptive contents.

Residual risk | Risk that remains after countermeasures and controls have been installed.

Resources | Protected objects in a computing system, such as files, computers, or printers.

Retro virus | A virus that attacks countermeasures, such as antivirus signature files or integrity databases.

Revocation | Stopping authorization for access to data.

RFC 1087: Ethics and the Internet | An acceptable-use policy statement as issued by the Internet Advisory Board and the U.S. government defining ethics and the Internet.

Risk | The likelihood that something bad will happen to an asset.

Risk management | The process of identifying, assessing, prioritizing, and addressing risks.

Risk methodology | A description of how risk is managed overall. It includes the approach, required information, and techniques to address each risk.

Risk register | A list of identified risks that results from the risk-identification process.

Rivest-Shamir-Adelman (RSA) | A digital signature algorithm that relies on the difficulty of factoring large numbers.

Rogue access point | A wireless LAN access point set up and configured by a hacker to fool users into connecting with it. The hacker may then use the connection to carry out an attack, such as a man-in-the-middle attack.

Role-based access control (RBAC) | An access control method that bases access control approvals on the jobs the user is assigned.

Rootkit | A type of malware that modifies or replaces one or more existing programs to hide the fact that a computer has been compromised.

Router | A device that connects two or more networks and selectively interchanges packets of data based on predetermined routes or path determinations.

Rule-based management | Managing the security of a network by defining network device rules about what is and is not acceptable.

S

Safeguard | Something built in to or used in a system to address gaps or weaknesses in the controls that could otherwise lead to an exploit.

Salt value | Random characters that can be combined with an actual input key to create the encryption key.

Sandbox | A strategy for separating programs and running them in their own virtual space.

Sarbanes-Oxley Act of 2002 | SOX or Sarbox for short, is a U.S. federal law requiring officers of publicly traded companies to have accurate and audited financial statements. SOX also requires proper security controls to protect financial records and insider information.

Scarcity | A social engineering attack that relies on victims' feelings that there might be a shortage (scarcity) of something or some form of access to pressure them into divulging information.

Screened subnet | *See demilitarized zone.*

Script kiddie | A person with little or no skill who simply follows directions to carry out an attack without fully understanding the meaning of the steps performed.

Search engine optimization (SEO) | Refers to the strategies used to make a site more browser friendly.

Secure European System for Applications in a Multi-Vendor Environment (SESAME) | A research and development project funded by the European Commission to provide single sign-on capability. SESAME was developed to address weaknesses in Kerberos.

Secure Hash Algorithm (SHA) | A set of cryptographic hashing functions developed by the U.S. National Security Agency.

Secure LDAP | A version of LDAP that uses SSL/TLS for all messages exchanged across the network.

Secure router configuration | A collection of settings that ensure that a router is allowing only valid network traffic to flow to and from valid nodes.

Secure Shell (SSH) | Commonly used protocol to set up secure logon sessions to remote servers.

Secure Sockets Layer/Transport Layer Security (SSL/TLS) | Cryptographic protocols that provide secure communications over a computer network. TLS succeeded its deprecated predecessor, SSL.

Secure Sockets Layer virtual private network (SSL-VPN) | A means of securing remote access to a secure website, or, in other words, a VPN that runs on the SSL and encrypts communications to a secure web server via a secure browser connection.

Security | A control, such as a policy or procedure, or a physical thing, such as a gate, that is used to protect something from risks, threats, or vulnerabilities.

Security administration | A group of individuals responsible for planning, designing, implementing, and monitoring an organization's security plan.

Security Assertion Markup Language (SAML) | An open XML standard used for exchanging both authentication and authorization data.

Security association (SA) | The basic element of ISAKMP key management. SA contains all the information needed to do a variety of network security services.

Security audit | An audit that focuses on security policies and controls.

Security awareness training | Training about security policies, threats, and handling of digital assets.

Security breach | Any event that results in a violation of any of the C-I-A security tenets.

Security control | Any mechanism or action that prevents, detects, or responds to an attack and thus reduces overall risk.

Security gap | The difference between the security controls in place and the controls needed to address all vulnerabilities.

Security information and event management (SIEM) system | A rich integrated set of tools that help collect, assess, and visualize a networked environment's state.

Security kernel | The central part of a computing environment's hardware, software, and firmware that enforces access control for computer systems.

Security kernel database | A database made up of rules that determine individual user's access rights.

Security operations center (SOC) | The team of individuals and the physical location where the team works.

Security orchestration, automation, and response (SOAR) | An integrated set of tools that help determine the security level of a networked environment, identify anomalies, and respond to issues in a structured manner.

Security policy | A set of policies that establish how an organization secures its facilities and IT infrastructure. Can also address how the organization meets regulatory requirements.

Self-assessment questionnaire (SAQ) | Defined by the PCI DSS, this is a series of yes-or-no questions used to guide the organization toward determining its own compliance with the standard's requirements.

Separation of duties | The process of dividing a task into a series of unique activities performed by different people, each of whom is allowed to execute only one part of the overall task.

Service bureau | A service provider that has sufficient capacity to offer outsourced wholesale services to smaller customers.

Service-level agreement (SLA) | A contractual commitment by a service provider or support organization to its customers or users.

Service Organization Controls (SOC) | Internal controls related to information technology.

Session hijacking | A network attack in which the attacker attempts to take over an existing connection between two network computers.

Session key | A unique key for each new communication session.

Shoulder surfing | Looking over people's shoulders as they enter codes at secure devices, such as a bank cash machine or a gas pump.

Simple Network Management Protocol (SNMP) | A nonsecure, connectionless UDP-based protocol that is used to transmit network management data between IP devices and an SNMP data collection server.

Simple substitution cipher | A cryptographic cipher in which each character is replaced with another character.

Simulation test | A method of testing a BCP or DRP in which a business interruption is simulated and the response team responds as if the situation were real.

Single-factor authentication | An authentication method that uses only a single type of authentication credentials.

Single point of failure (SPOF) | A single piece of hardware or software that must operate for the larger system or network to operate.

Single sign-on (SSO) | A method of access control that allows a user to log on to a system and gain access to other resources within the network via the initial logon. SSO helps a user avoid having to log on multiple times and remember multiple passwords for various systems.

Slow virus | A virus that counters the ability of antivirus programs to detect changes in infected files, slowing down the detection of the virus.

Smart card | A plastic card with authentication credentials embedded in either a microchip or magnetic strip on the card.

Smartphone | A cell phone that runs mobile communications software and supports voice, Internet browsing, email, and text messaging.

Smurf attack | A network attack in which forged ICMP echo request packets are sent to IP broadcast addresses from remote locations to generate DoS attacks.

Smurfing | A DoS attack that uses a directed broadcast to create a flood of network traffic for the victim computer.

Sniffing | The physical interception of data communications; eavesdropping.

Social engineering | A type of attack that relies on persuading a person to reveal information.

Social media | A blanket term that describes applications that enable people to interact with each other, including forums, message boards, blogs, wikis, and podcasts. These applications include Google+,

Facebook, Instagram, and YouTube.

Software as a Service (SaaS) | A model of program deployment or service where customers use applications on demand.

Software development life cycle (SDLC) | A popular method used to describe the process of planning, developing, testing, and deploying software applications.

Software vulnerability | An error or bug in software code that can be exploited.

Spam | Unwanted email or unsolicited messages.

Spear phishing | An email or instant message spoofing fraud attempt that targets a specific organization, seeking unauthorized access to confidential data.

Spim | Similar to spam of unsolicited messages but through an instant messaging service rather than email.

Spoofing | A type of attack in which one person, program, or computer disguises itself as another person, program, or computer to gain access to some resource.

Sprint | One of the small project iterations used in the agile method of developing software, in contrast with the usual long project schedules of other methods of development software.

Spyware | Software that gathers user information through the user's Internet connection without the user's knowledge.

SQL injection | A form of web application attack in which a hacker submits SQL (structured query language) expressions to cause authentication bypass, extraction of data, planting of information, or access to a command shell.

SSL handshake protocol | A process that creates the first secure communications session between a client and a server.

Standard | A mandated requirement for a hardware or software solution that is used to deal with a security risk throughout the organization.

State | Information that describes the current status of a network connection that is used by firewalls to make decisions on whether to pass or drop network packets.

Stateful inspection firewall | A firewall that examines the state of a connection, as well as simple address, port, and protocol rules, to determine how to process a packet.

Stateful matching | A technique of matching network traffic with rules or signatures based on the appearance of the traffic and its relationship to other packets.

Static environment | System that does not change very much or at all after deployment.

Stealth virus | A type of virus that uses a number of techniques to conceal itself from the user or detection software.

Steganography | The art and science of writing hidden messages.

Store-and-forward communications | The technique of relaying information between two or more users by intermediate storage. Delivery from sender to a central storage is immediate, but the final transmission to the recipient depends on availability and a request for the stored information.

Stream cipher | Cryptographic cipher that encrypts a single byte (or bit) at a time.

Structured walk-through test | This type of test involves a group of stakeholders collectively reading through a response plan and discussing how they would implement each step. Also called a tabletop exercise.

Subnet | A partition of a network defined by devices that share the same network address portion of the IP address.

Subnet mask | A network configuration parameter that defines the dividing line between the network and host addresses for IPv4 addresses. The mask is a 32-bit number that is set to all "1"s for the network bits and all "0"s for the host bits.

Subnet mask address | The complement to an IP address that defines the IP network number and IP host address.

Substitution cipher | An encryption cipher that replaces bits, characters, or blocks of information with other bits, characters, or blocks.

Succession planning | The act of planning who will step in if key personnel are incapacitated or unavailable.

Swapfile | A file that an operating system uses to temporarily store parts of main memory when there is insufficient memory to handle the requirements of running programs.

Switch | A network device that connects network segments, creating a direct connection between a sending and a receiving port.

Symmetric key cryptography | A type of cryptography that cannot secure correspondence until after the two parties exchange keys.

SYN-ACK | A specific network TCP message used to respond to (ACK) a request to establish a network connection (SYN). This type of message is step two in the three-step connection handshake.

Synchronous token | device used as a logon authenticator for remote users of a network.

SYN flood | A A DoS attack that fills up a computer's connection table by sending a flood of unacknowledged connection requests. Once the connection table fills up, the computer cannot respond to any new legitimate connection requests.

System development life cycle (SDLC) | A formal process of managing the software development process.

System infector | A type of virus that targets key hardware and system software components in a computer and is usually associated with system startup processes.

System life cycle (SLC) | A method used in systems engineering to describe the phases of a system's existence, including design, development, deployment, operation, and disposal.

System owner | The person responsible for the daily operation of a system and for ensuring that the system continues to operate in compliance with the conditions set out by the authorizing official.

T

Tailgating | The act of following an individual closely to sneak past a secure door or access area.

Technical control | A control that is carried out or managed by a computer system.

Technology protection measure (TPM) | Technology used to restrict access to a resource.

Telephony | The field of technology that includes the development and deployment of voice communication solutions.

Telephony denial of service (TDoS) | A variation of DoS attacks but launched against traditional and VoIP telephone systems. A TDoS attack disrupts an organization's use of its telephone system through a variety of methods.

Telnet | A nonsecure application that supports remote terminal access in cleartext transmission.

Temporal isolation | A method of restricting resource access to specific periods of time. You may see temporal isolation more commonly described as time-of-day restrictions.

Temporal Key Integrity Protocol (TKIP) | An encryption method used on WPA to replace WEP.

Terminal Access Controller Access System (TACACS) | A remote access client/server protocol that provides authentication and authorization capabilities to users who are accessing the network remotely. It is not a secure protocol.

Terminal Access Controller Access System Plus (TACACS+) | A Cisco proprietary remote access client/server protocol that provides authentication, authorization, and accounting.

Thick client | Computer software that handles user I/O and most business logic (data processing), using the server for only data storage and data access.

Thin client | Computer software that handles only user I/O functionality and depends on servers to perform most business logic (i.e., data processing), data storage, and data access.

Threat | Any action that could damage an asset.

Threat analysis | The process of identifying and documenting threats to critical resources.

Threshold | A value that indicates a change from normal to abnormal behavior. In the case of failed logon attempts, a threshold of five means that, when a user fails to log on five times, the action should be considered abnormal.

Time-based one-time password (TOTP) | An example of HOTP, this algorithm combines a time stamp with a hashed value to reduce vulnerability to replay attacks.

Time-based synchronization system | An authentication method in which a token's internal clock is synchronized with a server's clock to generate matching values.

Time-of-day restrictions | *See temporal isolation.*

Time offset | The amount of time, generally in hours, that a time should be offset from a standard time zone, such as Universal Coordinated Time, to express a time stamp as a time local to a specific time zone.

Time stamp | Data that identifies a date and time (often with the precision of milliseconds) to record when an event occurred.

Time-stamping | Providing an exact time when a producer creates or sends information.

Token | A physical device that transmits a secret code to a user to authenticate the user. Can be a hardware-device token or a software-generated token.

Total risk | The combined risk to all business assets.

Transition function | The transition from one state to another state.

Transitive access | Attacking the desired target system or service indirectly by first compromising a system trusted by the target.

Transitive trust | An authentication method in which the initial sign-on credentials are forwarded by request to other trusted servers.

Transmission Control Protocol/Internet Protocol (TCP/IP) | A popular suite of protocols that operate at both the Network and Transport Layers of the OSI Reference Model. TCP/IP governs all activity across the Internet and through most corporate and home networks.

Transport encryption | The process of securing communication in transit, generally done by software.

Transposition cipher | An encryption cipher that rearranges characters or bits of data.

Trivial File Transfer Protocol (TFTP) | A connectionless, UDP-based file transfer protocol used for quick and small file transfers between two IP devices.

Trojan | A malicious software code that appears benign to the user but actually performs a task on behalf of a perpetrator with malicious intent.

Trojan horse | *See Trojan.*

True downtime cost | *See opportunity cost.*

Trust | Confidence in the expectation that others will act in your best interest or that a resource is authentic. On computer networks, trust is the confidence that other users will act in accordance with the organization's security rules and not attempt to violate the stability, privacy, or integrity of the network and its resources.

Trusted operating system (TOS) | A type of operating system that includes additional controls to address the additional security needs of systems that handle extremely sensitive information.

Two-factor authentication | An authentication method that uses two types of authentication credentials. See also *two-step authentication*.

Two-step authentication | *See two-factor authentication.*

Typo squatting | *See URL hijacking.*

U

Unified communications | The integration of multiple types of enterprise communications, such as instant messaging, voice, video, and data, all on a single network.

Unified messaging (UM) | The storage of fax, email, and voice communications in a single location.

Unified threat management (UTM) | Devices used to provide filtering, plus many additional security services.

Uptime | The total amount of time the IT system, application, and data are accessible.

Urgency | A social engineering attack that uses a sense of urgency or an emergency stress situation to get someone to do something or to divulge information.

URL filter | Firewall filtering rules that filter web traffic by the URL, as opposed to the IP address.

URL hijacking | The act of registering and "squatting" a slightly wrong URL in the hopes a user mistypes the intended URL.

USA Patriot Act | An act passed into law in response to the terrorist attacks of September 11, 2001, which significantly reduced restrictions on law enforcement agencies' gathering of intelligence within the United States; expanded the Secretary of the Treasury's authority to regulate financial transactions, particularly those involving foreign individuals and entities; and broadened the discretion of law enforcement and immigration authorities in detaining and/or deporting immigrants suspected of terrorism and related acts.

USB token | A hardware device used for authentication that plugs into a computer's USB port. This device provides authentication credentials without the user's having to type anything.

User acceptance | The last stage of software development, when users work with the software, simulating real-world use.

User assigned privilege | The most detailed authorization policy, it assigns specific privileges to the individual user.

User Datagram Protocol (UDP) | A communication protocol that is connectionless and popular for exchanging small amounts of data or messages.

Username | The most common method to identify a user to a system. It is usually a character string that represents a person or group of people who access a computer system.

V

Vendor-neutral certification | A type of certification that covers concepts and topics that are general in nature and do not focus on a specific product or product line.

Vendor-specific certification | A type of certification that helps to identify professionals who possess in-depth product knowledge. Many organizations use these certifications, along with vendor-neutral certifications, when evaluating prospective employees and personnel.

Vernam cipher | The only unbreakable cryptographic cipher. Also called a one-time pad.

View-based access control (VBAC) | Limiting users' access to database views, as opposed to allowing users to access data in database tables directly.

Vigenère cipher | An encryption cipher that uses multiple encryption schemes in succession. For example, every fifth letter could be encrypted with its own substitution cipher.

Virtual LAN (VLAN) | The broadcast domain in Ethernet in which all workstations are on the same logical LAN.

Virtual private network (VPN) | A method of encrypting IP packets from one end to another, as in a tunnel.

Virus | A software program that attaches itself to or copies itself into another program for the purpose of causing the computer to follow instructions that were intended by the original program developer.

Vishing | The act of performing a phishing attack by telephone to elicit personal information.

VPN concentrator | Network device acting as a type of router specializing in VPN connections.

Vulnerability | A weakness that allows a threat to be realized or to have an effect on an asset.

Vulnerability scanner | A software tool that collects information about any known weaknesses that exist on a target computer or network.

Vulnerability testing | A process of finding the weaknesses in a system and determining which places may be attack points.

Vulnerability window | The amount of time from when a software vendor releases a security bulletin about a software vulnerability to when the IT asset is actually patched.

W

Wannabe | *See gray-hat hacker.*

War chalking | The act of creating a map of the physical and geographic location of any wireless access points and networks.

Wardialer | A computer program used to identify the phone numbers that can successfully make a connection with a computer modem.

War driving | A method for discovering wireless networks by moving around a geographic area with a detection device.

Waterfall model | A software development model that defines how development activities progress from one distinct phase to the next.

Watering hole attack | The act of compromising with malicious code a third-party website known to be visited by the targeted individuals or company. The attacker must then wait for the target to visit the victim site and for the planted code to aid in attacking the target systems.

Web application attack | *See application attack*.

Web applications | Applications that users access via a network, often the Internet, using a web browser.

Web defacement | *See web graffiti*.

Web graffiti | Refers to a person's gaining unauthorized access to a web server and altering one or more pages of a website on the server. Also called web defacement.

Web security gateway | A device that performs URL filtering but does not examine the content of the packet.

Whaling | A phishing attack that targets the executive user or most valuable employees, otherwise considered the "whale" or "big fish." Also often called "spear phishing" as in a highly focused phishing attack.

White-box testing | Security testing that is based on knowledge of the application's design and source code.

White-hat hacker | An information security or network professional who uses various penetration test tools to uncover or fix vulnerabilities. *See also ethical hacker.*

Whitelisting | The act of maintaining a list of trusted websites. All messages and connection requests from sites not in the whitelist are ignored.

Wi-Fi | An alliance among wireless manufacturers to brand certified products that interoperate with wireless LAN standards. A Wi-Fi hotspot is a wireless LAN access location.

Wi-Fi Protected Access (WPA) | Current encryption for wireless networks. Much stronger than WEP, WPA is the recommended encryption for wireless use.

Wired Equivalent Privacy (WEP) | Legacy encryption for wireless networks. WEP is weak and does not provide sufficient protection for most traffic.

Wireless access point (WAP) | A radio transceiver device that transits and receives IP communications via wireless LAN technology.

Wireless LAN (WLAN) | A local area network that uses radio transmissions, instead of wires or cables, to connect computers and devices.

Wiretapping | Intercepting communication sent via a wired connection.

Workstation | A desktop computer, a laptop computer, a special-purpose terminal, or any other device that connects to a network.

World Wide Web (WWW) | A collection of documents that are hyperlinked among one another and accessed using the Internet.

World Wide Web Consortium (W3C) | An organization formed in 1994 to develop and publish standards for the World Wide Web.

Worm | A self-replicating piece of malicious software that can spread from device to device.

X

Xmas attack | An old attack of sending a deliberately malformed network packet hoping that the receiving network device responds unexpectedly (e.g., rebooting or crashing). The malformed packet includes several TCP header bits set to "1," or turned on, like the lights of a Christmas tree.

XML injection | A web application attack in which the attacker injects XML tags and data into a database in an attempt to retrieve data.

XTACACS (Extended Terminal Access Controller Access System) | An extension of the TACACS remote access client/server protocol that provides authentication and authorization capabilities to users who are accessing the network remotely. It is not a secure protocol.

Z

Zero day | A new and previously unknown attack for which there are no current specific defenses. "Zero day" refers to the newness of an exploit, which may be known in the hacker community for days or weeks. When such an attack occurs for the first time, defenders are given zero days of notice (hence the name).

Zero trust network | A network in which no user or device is implicitly trusted.

Zone transfer | A unique query of a DNS server that asks it for the contents of its zone.

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